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THE SCIENCE AND PRACTICE OF SURGERY

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SEVENTH EDITION

With 810 Illustrations

VOLUME I.

GENERAL SURGERY

LONDON

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104 GLOUCESTER PLACE

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Reprinted

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Dedicated

To our Friend and Teacher
the late
SIR GEORGE MAKINS, G.C.M.G., C.B.
In Tribute to a Great Man

First Edition . . . 1927
Second ,, . . . 1928
Third ,, . . 1930
Fourth 1932
Fifth ,, . . . 1934
Sixth ,, . . . 1937
Seventh ,, . . 1941
,, ,, *Reprinted* . 1944

Printed in Great Britain

PREFACE TO THE SEVENTH EDITION

THE preparation of this present edition has been undertaken entirely since the declaration of war. This has led to certain difficulties as enemy action has rendered some illustrations and notes inaccessible. The problem of the discussion of war surgery is one which we have kept prominently before us, and we have introduced a short appendix on War Surgery at the end of the first volume. This is in no sense comprehensive, for many subjects which can be reasonably considered as coming under the heading of war surgery were already present in the text. The appendix must therefore be regarded in the nature of an amplification of these articles, while we have transferred into it from elsewhere in the book the discussion of the treatment of "gas cases" and of certain aneurysms which are largely seen as sequelæ of war injuries.

The whole of the book has been completely and carefully revised, and many subjects entirely re-written. In particular, large alterations and additions have been made in the sections on cleft palate, blood grouping and transfusion, sympathetic surgery and injuries. It has been thought advisable to remove some of the preliminary discussion of bacteriology and the description of amputations which are only of historic interest.

The authors feel confident that the work will still maintain its place in the field of surgical literature as providing enough material for the student to pass his elementary and advanced examinations. It will also serve as a book of reference to the qualified practitioner.

There remains the pleasant task of acknowledging our thanks and indebtedness to those friends and colleagues who have assisted us in the preparation of this edition. The sections on ear, nose and throat surgery, ophthalmic surgery and anæsthesia have been revised and re-written by Mr. Neilson, Mr. Gimblett and Dr. Potter. Dr. Fildes having retired, Dr. Bertram Shires has kindly undertaken the task of revising the section on X-rays. Dr. T. Anwyl-Davies, Physician in charge of the Venereal Department at St. Thomas's Hospital, has fully revised all the sections dealing with venereal disease, and provided some extra illustrations for this part of the work; while the Surgery Departments of the Universities of Liverpool and Birmingham, and the Photographic Department at St. Thomas's Hospital have also supplied us with some excellent photographs.

Mr. Charles Rob, M.B., M.Ch. (Cantab.), F.R.C.S. (Eng.), Surgical Tutor and Registrar at St. Thomas's Hospital, has read all the proofs and to him we are indebted for several very valuable suggestions; while to Messrs. J. & A.

Churchill Ltd. and to Mr. J. Rivers of that firm we must acknowledge our gratitude for their usual courtesy, helpfulness and patience.

We feel that we cannot let this edition go to press without alluding to the death of the artist, Mr. Thornton Shiells. His skill in preparing drawings for illustrating medical and surgical publications was well known, and he was responsible for most of the illustrations in our original edition.

W. H. C. R.
P. H. M.

HARLEY STREET,
LONDON, W.1.

PREFACE TO THE FIRST EDITION

In producing this work the authors have had two main objects in view, the first being to place before the student a book which is sufficiently comprehensive to provide him with all that he will require in passing both his ordinary surgical examinations and any higher examinations to which he may aspire, such as the Fellowship of the College of Surgeons ; and the second, to present a book which may be of value as a work of reference to the medical practitioner.

Surgery is now a vast subject, and it has always fallen somewhat naturally into the divisions of Surgical Anatomy, Surgical Pathology, Diagnosis and Operative Surgery, together with all their side issues. We have recently come across the following quotation in a work of fiction with reference to certain imaginary members of the profession who are there described as " Men who, led to take up surgery by the hope of gain and notoriety, have given themselves no time to learn its scientific principles ; showy operators who diagnose with the knife and endeavour to dictate to nature and not to assist her." Feeling that there might be a certain modicum of truth in this description, we have endeavoured, as far as possible, to give a full account of the surgical pathology and the scientific side of the subject as well as the more practical details, such as diagnosis and treatment.

Surgical after-treatment is a subject which is often greatly neglected in both text-books and bedside teaching, and though, of course, it can only be learnt really thoroughly by actually having to undertake it, we have tried, as far as possible, to place before the reader reasonable and accepted methods for the after treatment of operation cases.

Modern medicine, and surgery also, are very much coloured by biological chemistry, and a multitude of chemical tests and laboratory examinations are now employed in connection with surgical cases. It is a deplorable fact that in many instances such methods are used to establish a diagnosis with complete neglect and disregard of the clinical aspects and personal subjective symptoms of the patient ; we feel that it cannot enhance the interests or the reputation of the profession if the clinical and human elements in surgery are lost sight of, and have therefore endeavoured to show that the practice of surgery is an art, and that it never can be an exact science, entirely relegated to the test tubes and appliances of a biochemical laboratory.

We have essayed as far as possible to give some account of the ways in which these various chemical processes and biological tests should be employed and of their relative values in diagnosis, but we have made no attempt to give in detail the methods of performing such tests. This is partly owing to limitation of space, but still more because we feel strongly that if the results of these complicated chapters in chemistry are to be of value in the diagnosis and treatment of patients. they must be performed by absolute experts, and it is not wise to encourage either the student or the practitioner to endeavour to perform them for himself.

We have made a practice throughout both volumes, where applicable, of prefacing each chapter with a short account of the applied surgical anatomy and physiology of the region or organ discussed. These sections are printed in small type, not in order in any way to detract from their importance, but from considerations of space, and to differentiate them from the pathological and clinical portions of the work.

An account of the various operations in surgery is not essentially part of a work on surgery, and there are many excellent books dealing with the subject. We have, nevertheless, included a short account of the salient points of all the more important operations with their indications and difficulties, in the hope that, for the student at any rate, it will render the book complete and increase its value.

In many instances there are methods of treatment and operations which, though very seldom practised nowadays, are nevertheless worthy of consideration for their classical associations and because of the resulting tendency for them to be used as examination tests. We have, therefore, as far as possible referred to all such obsolete methods, but in the shortest possible fashion, giving the reasons for their gradual disappearance from modern practice.

With the added object of rendering the work as complete as possible we have included short chapters on diseases of the eye, diseases of the ear, nose and throat, on anæsthetics, on X-rays in diagnosis and treatment, and on the surgical aspects of obstetrics and gynæcology. In each instance these chapters have been written more with a view to assisting those who are studying or practising general surgery rather than the specialities therein contained.

There remains the pleasant task of acknowledging our indebtedness and thanks to those of our colleagues and others who have assisted us in the preparation of this work.

Mr. R. H. O. B. Robinson, B.A., M.B., B.Ch. (Cantab.), F.R.C.S. (Eng.), Surgeon in Charge of Out-patients to St. Thomas's Hospital and Assistant Surgeon to the City of London Hospital for Diseases of the Chest, has written part of the four chapters on Injuries of Bones, Injuries of Joints, Injuries of the Upper Limb, and Injuries of the Lower Limb. He has also read through the whole of the proofs for us and given us many valuable suggestions.

Mr. W. H. Battle, F.R.C.S. (Eng.), Consulting Surgeon to St. Thomas's Hospital, to whom we were both House Surgeons, has very kindly placed the whole of his very large collection of clinical photographs and pictures at our disposal, and we have drawn many of our illustrations from this source.

Mr. D. F. A. Neilson, B.A. (Cantab.), F.R.C.S. (Eng.), Assistant Surgeon to the Ear, Nose and Throat Department of St. Thomas's Hospital, Aural Surgeon to the Freemason's Hospital and London Fever Hospital, late Assistant Surgeon to the Ear, Nose and Throat Department of the Royal Free Hospital, and Registrar to the Ear, Nose and Throat Department of University College Hospital, has written the three chapters on Diseases of the Ear, Nose and Throat.

Mr. C. L. Gimblett, M.A., M.D., B.Ch. (Cantab.), F.R.C.S. (Eng.), M.R.C.P. (Lond.), Surgeon to the Royal Westminster Ophthalmic Hospital, and late Senior Ophthalmic Surgeon to the Royal Northern Hospital, has undertaken the whole of the chapter on Diseases of the Eye.

Dr. Geoffrey Fildes, M.B., Ch.B. (Vict. Manch.), D.M.R.E. (Cantab.), Physician in Charge of the Radiological Department at St. Thomas's Hospital, has written the chapter on X-rays in Diagnosis and Treatment.

Dr. A. F. Potter, Honorary Anæsthetist to St. Thomas's Hospital and to the Royal Albert Dock Hospital and late Hon. Asst. Anæsthetist to the Royal Dental Hospital, is responsible for the chapter on Anæsthesia.

We are also indebted to Mr. Richard Warren, M.D., M.Ch. (Oxon.), F.R.C.S.

(Eng.), for permission to use certain illustrations from his work, " A Text-Book of Surgery."

To Professor Dudgeon, Dr. Bamforth, Dr. A. L. Urquhart, and Dr. John Taylor we are indebted for the loan of microscopic preparations and pathological material, and to the Museum Committee of St. Thomas's Hospital we owe our thanks for permission to make use of the specimens in the Shattock Museum.

From Colonel Harrison and Dr. T. Anwyl-Davies we have derived much help in the matter of the treatment of venereal diseases, and to the former we tender our thanks for permission to use several illustrations.

Prof. De Wesselow, Physician to and Professor of Medicine at St. Thomas's Hospital, has kindly assisted us with regard to the various tests for renal efficiency.

Dr. Dore, Consulting Physician to the Skin Department at St. Thomas's Hospital, has helped us greatly with advice and illustrations relating to Diseases of the Skin, and to Messrs. Millward and Yule we tender our thanks for photographs which they have taken for us.

We are indebted to Messrs. Allen and Hanbury for the loan of certain blocks.

Messrs. Thornton Shiells and Ford have greatly assisted us by the painstaking way in which they have produced drawings of microscopic slides and specimens, at the skill of which we can only marvel. We are also much indebted to Messrs. J. & A. Churchill for their help and care in the publication of the work.

W. H. C. R.
P. H. M.

HARLEY STREET,
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THE SCIENCE AND PRACTICE OF SURGERY

CHAPTER I

GENERAL SURGICAL PROCEDURES

Examination of a surgical patient—Asepsis and antisepsis—Technique in operative surgery—Preparation of patients for operation—After-treatment of operation cases—Post-operative complications, their diagnosis and treatment.

Examination of a Patient. The inclusion in a surgical text-book of all diseases is both undesirable and impossible, and in this volume an attempt has been made to indicate to the would-be surgeon, lucidly and briefly, the surgical conditions which he may be called upon to investigate during his career, and to outline not only the physical signs and symptoms by which the

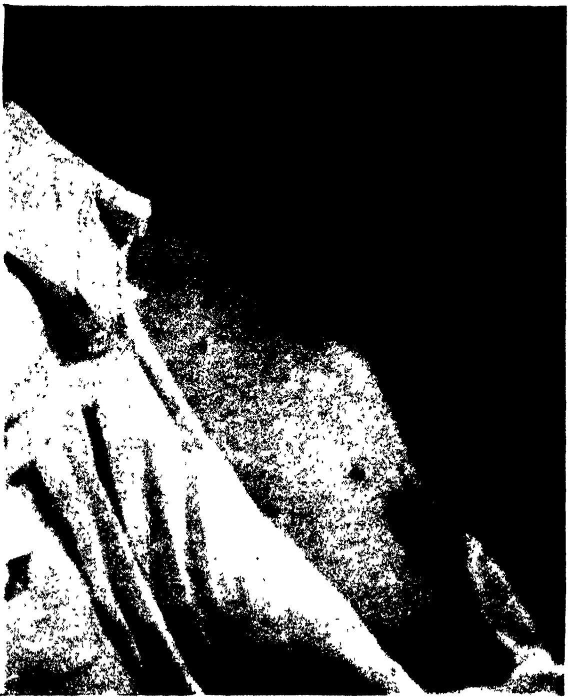


FIG. 1. Fibro-adenoma of the breast, visible on inspection. The overlying skin is normal and not puckered, showing that it is not a carcinoma. The definition of the edges eliminates an inflammatory origin.

case can be diagnosed, but also the pathological conditions from which these signs result, and, moreover, to indicate on what lines treatment may be undertaken for the amelioration of the patient's condition. But it must be understood that a detailed explanation of the points of differential diagnosis between these various diseases is out of place in a text-book of general surgery, and to ascertain both these and the full description of clinical methods used in their investigation, the reader is referred to special text-books on these subjects.

Below is given a brief scheme indicative of the general lines on which a patient should be approached and his case investigated.

The first question that a student of surgery, or for that matter a surgeon, has to ask himself on being confronted with a sick patient is as to the cause of the trouble. "Is this lesion due to trauma, infection, or new growth?" And it is on the accurate answer to this query that the life of the patient, and incidentally the success of the practitioner, frequently may depend. It cannot be impressed too strongly on the medical student that nearly all disease is due to one of these three causes, *trauma*, *infection* or *new growth*, and that the exact cause can be elicited only in the majority of cases after a careful and systematic examination not only of the local condition, but of the whole body of the patient. It is necessary that the bearing and conduct of the surgeon should convince the patient of his interest and sympathy, and so win complete confidence.

Turning to the examination itself, this should be conducted gently and with due regard to the patient's feelings and comfort, the attention of the patient being held meanwhile by obtaining a *detailed history of the case*, which is always of the utmost value.

The following routine should be followed in every case:—

1. *Inspection*, both local and general, is of the greatest value, and should be made in a good light without being too close to the patient.
2. *Palpation* of the local lesion and its immediate area should be carried out next in order to ascertain the shape, consistency, attachments and limits of the local condition. Similar examination of distant parts may be indicated.
3. *Percussion* may be necessary locally.
4. *Auscultation* may be necessary locally in a few cases. Both of these are essential in *the examination of the cardiac and respiratory systems and the abdomen*, which should be carried out as a routine in all cases.
5. *Examination of the urine* is an essential part of the investigation of a case, as is also the examination of the *central nervous system*.

Rectal or pelvic examination should be made in all cases of abdominal diseases.

It will be seen from the foregoing that the surgeon must of necessity be a physician also if he is to give to his patients that thorough preliminary examination which alone can justify his confidently recommending resource to the knife as the only certain means of cure of the condition on which his opinion is sought.

Asepsis and Antisepsis. As will be explained, sepsis results from the infection of the tissues by micro-organisms (Chapter III.), and in order to prevent such a calamity resulting during operations very stringent precautions have to be taken by all parties concerned. On those accustomed to the orderly quiet and cleanliness of the modern operating theatre it is difficult to impress the necessity for routine measures, which are essential to prevent a return of the virulent post-operative suppuration which was all too frequent in the days before Lord Lister, by the introduction of antiseptics into surgery, inhibited the growth of the bacteria which Pasteur had shown to be the cause of infection in operation wounds; but upon those who saw something of the surgical conditions prevailing in the field during the last war that necessity was impressed in a forceful and dramatic manner, and with it came the realisation of how very necessary is the attainment of those essential precautions against infection, and how very simple they need be to be effectual in actually excluding organisms; whereas, once these have gained admission to the tissues, it is almost impossible to eliminate them or even effectually inhibit their growth.

Asepsis aims at the exclusion of all micro-organisms from the wounds by the use of dressings and instruments sterilised by heat, usually in the form of boiling water or steam, and by the thorough cleansing of the skin of the patient, surgeons and assistants.

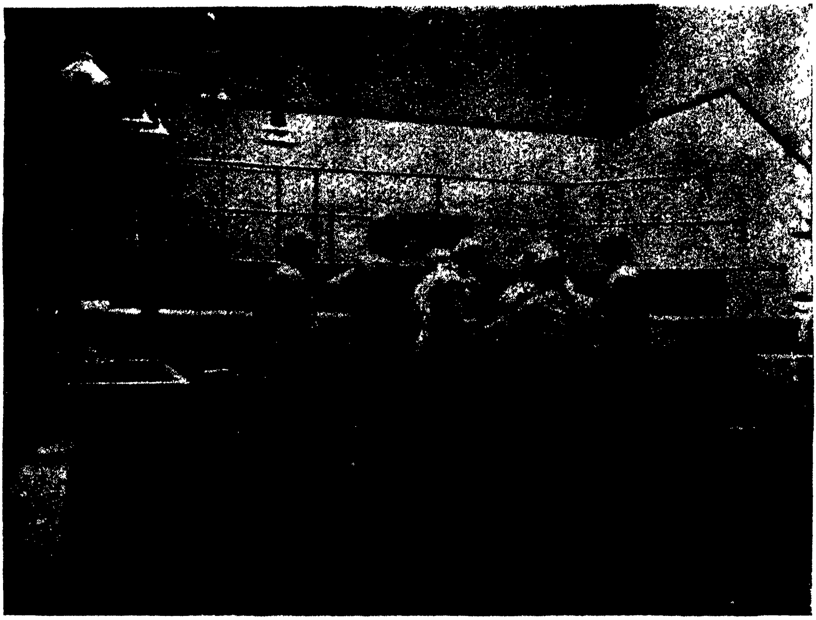


FIG. 2. An Aseptic Operating Theatre.

Antisepsis aims at the destruction of the organisms, or at least the inhibition of their growth, after they have gained access to the operation area, by the use of chemical substances known as antiseptics.

Inasmuch as these antiseptic substances frequently can be used only in strength sufficient to inhibit the growth of the bacteria, and as even in this strength they exert an irritant action on the tissue cells, which in greater concentration they destroy, the aseptic method is preferable in practice, as here nothing is employed to damage tissue cells and impede repair, organisms are excluded, and no misplaced faith is given to the uncertain action of chemical substances on their growth.

The majority of surgeons nowadays rely, therefore, on sterilisation by some form of heat to exclude organisms from instruments and dressings, but inasmuch as this method cannot be used in cleansing the skin of either the surgeon or the patient, antiseptics in various forms have to be relied on for this purpose. Moreover, although experience has shown that sterile isotonic saline is by far the least harmful lotion to apply to cut surfaces, and that it can be used safely under all conditions, yet there are many surgeons who prefer weak antiseptic lotions for this purpose, and a list of the various lotions in common use is appended.

Sterile normal saline solution is approximately isotonic with the blood plasma, and therefore may be employed with impunity at or slightly above body temperature (100°–115° F.), as it exerts no irritating or devitalising effect on the tissue cells. It is prepared by dissolving sodium chloride in water in the proportion of 1 drachm of the salt to each pint of water; the whole must be sterilised by boiling and then allowed to cool, or else cooled by adding cold sterile saline. This lotion always should be used for moistening the peritoneum of exposed bowel, in skin grafting, etc., and may be employed with great advantage as a hand lotion throughout the whole operation; this, indeed, is the practice of most surgeons of the aseptic school.

Sterile water is also non-irritant, but not being isotonic with the tissues, it causes osmosis from these, and is therefore not so good as normal saline. Like saline, it should be employed at or just above body temperature, but if used as a hæmostatic it should, like saline, be at a temperature of from 125°–135° F.

Sterile paraffin and **glycerine** are non-irritant lubricants and may be used to lubricate instruments for their passage through mucous canals, *i.e.*, catheters, cystoscopes, sigmoidoscopes, etc., or as a dressing to raw and granulating wounds, where they prevent the gauze adhering to the delicate tissues and so stop damage when the dressing is stripped off.

Alcohol employed as 70 per cent. spirit solution is a valuable antiseptic, and on its use probably depends the efficacy of the various alcoholic solutions employed in sterilising the skin of the patient and surgeon. It should be in contact with the surface for at least five minutes, and to be efficient must be applied to the *dry* skin. If used for sterilising phials of catgut, scalpels, etc., these should be immersed at least half an hour before use.

Biniodide of mercury in alcoholic solution is the most popular and probably the most efficient antiseptic lotion in general use. It is a powerful germicide, does not tarnish instruments, and as it does not react much with albumen, can penetrate the tissues more thoroughly than those salts which coagulate albumen and so form a film on the surface of the wound, which prevents the antiseptic penetrating efficiently into the tissues; this is the case with perchloride and other mercurial salts, picric acid, and to some extent carbolic. If used for application to the tissues, the aqueous solution (1–1,000) is less irritating and more efficient in penetrating power than the more expensive alcoholic variety.

Iodine solution, usually employed to sterilise the skin in the form of the tincture (2½ per cent. in alcohol), is an efficient but irritating antiseptic, and its application to wounds is painful, though it is commonly employed as a first aid dressing in factories, etc. Like all alcoholic antiseptic solutions, it must be applied to a dry surface to be efficient. A 1 per cent. solution in potassium iodide is used in the sterilisation of catgut sutures and ligatures.

Picric acid in a 2 per cent. alcoholic solution is efficient as an antiseptic for preparation of the patient's skin, which it colours a deep yellow, and as the surface albumen is deposited and the skin in some mild degree tanned by the picric, this yellow colour takes some weeks to wear off; thus this method of skin preparation is unsuited for the face and neck.

A 1 per cent. aqueous solution is of some value as a first dressing for burns and scalds (Chapter IV., p. 61). Occasionally both the above antiseptics give rise to toxic rashes of an erythematous type which may resemble scarlet fever, but cause intense irritation and may be followed by extensive desquamation.

Perchloride of mercury in a 1–500 or 1–1,000 aqueous solution was a very popular antiseptic, but is more toxic and is not so efficient as biniodide, which has largely superseded it, and which, in addition, has the advantage of not tarnishing instruments. Like most mercury salts, it combines with steel and silver, and therefore must not be brought in contact with instruments.

Carbolic acid is the oldest of the antiseptics of the modern school, having been popularised by Lord Lister. It is, however, of poor germicidal power when compared with other antiseptics, and though it undoubtedly inhibits the growth of most micro-organisms if left in contact with them for long periods, yet in solutions strong enough to ensure this (1–20) it is both toxic to the tissues and even to the individual; for it may produce both gangrene, especially of fingers and toes, and nephritis, the urine in this latter case being green in colour and the patient showing signs of toxæmia, such as breathlessness and a rapid weak pulse.

The 1–20 solution is, however, valuable for the storing of sterile ligatures to prevent organisms gaining access, though it undoubtedly tends to rot the fabric. Pure carbolic is a potent antiseptic which deliquesces, and is locally anæsthetic if applied to the tissues, in which it causes a painless superficial necrosis, the area being covered with a white slough.

Liquor sodae chlorinatae and **Eusol** are excellent for cleansing sloughs from foul wounds, but inasmuch as the hyperchlorous acid and chlorine, on which their efficacy as cleansing agents depends, destroy epithelium, they must be discontinued as soon as the wound is clean or they prevent healing.

Camphenol is a powerful antiseptic prepared by mixing pure carbolic and camphor in equal parts, when these deliquesce and produce an oily greenish liquid ; it is of value in dressing large septic wounds, where a painless dressing and stoppage of absorption by superficial necrosis of tissue are desired, as in carbuncles when the sloughs have been removed.

Hydrogen peroxide, usually used in a solution giving off 10 volumes of nascent oxygen when in contact with organic matter, is a valuable antiseptic in dealing with anaerobic micro-organisms. It also cleanses wounds by its mechanical action when bubbling off oxygen. It is not suitable for use in closed cavities, as it distends these and may strip up the surrounding tissues and convey infection to the deeper parts. It is valuable as a styptic and in loosening blood-soaked dressings. The water left after the oxygen has bubbled off should be cleaned away from the wound.

Formalin. A 40 per cent. aqueous solution of formaldehyde is a powerful antiseptic, and if applied in this strength produces immediate death of tissue with a black slough. It is sometimes thus used to cleanse the surface of septic wounds. It is more usually employed as a solution of a strength of about 4 per cent., but is very irritant and pungent. The vapour is used for disinfecting rooms and sterilising cystoscopes and catheters.

Flavine and **Acriflavine,** 1–1,000 in alcoholic solution, are powerful and non-irritant germicides, much used in dressing septic wounds.

Lysol (1 or 2 per cent.), Creolin, Izal, Cyllin, Dettol, are all coal-tar derivatives, of which the most used is lysol ; this, being derived from the action of coal-tar and alkalies, may be used for its soapy properties as well as an antiseptic. Pure lysol is valuable for keeping knives in, as it neither rusts nor blunts them, and many surgeons use it for sterilising scalpels ; it has, however, the disadvantage that it renders them slippery.

Sources of Infection. It is now generally conceded that infection of all operation, and for that matter other wounds, is the result of invasion by micro-organisms from some " outside " source, it being understood that the term " outside " includes the cutaneous and mucous surfaces, *i.e.*, the free surfaces which are not normally in contact with the tissues, and are, moreover, covered with micro-organisms. As a matter of fact, " auto-infection " from the skin is of rare occurrence, presumably due to an acquired immunity from the toxins of these organisms continually being absorbed into the system, and though it should be carefully guarded against at operations, auto-infection from skin surfaces is not a matter of great import.

Very different, however, is the danger of infection from other " outside " sources, and before discussing the methods used in combating these it will be well to consider briefly the possible sources of such infection. These are :—

1. The skin of the surgeon and his assistants, where, in the fissures and glands, numerous micro-organisms are present which it is almost impossible efficiently to dislodge. The mucous membranes of the mouth and nose must not be forgotten as sources of infection.

2. The skin and mucous membranes of the patient have already been mentioned, but especial care must be taken to exclude infection in those cases where the intestinal tract is opened during operation.

3. The clothing of the surgeon, assistants and patient are potent sources of infection, and for this reason as much as possible should be removed before entering the operating theatre, and the remainder covered by an overall of washable and easily sterilised material. The same applies to bedclothes.

4. Instruments, trolleys, tables, basins, etc., should be of glass or metal and capable of being sterilised by heat.

5. Sutures, ligatures and dressings must be capable of ready sterilisation, if possible by heat.

6. Saline solutions or antiseptic lotions used for applying to the wound surfaces must be sterile, and so need to be prepared from boiling or freshly-boiled water.

7. The air, which was at one time thought to be a potent source of infection, is now known to be little likely to convey micro-organisms to the wound in an operating theatre, provided it is still. Draughts, dust, undue movement or talking should be avoided in operating theatres, and similarly in emergency operations in private houses no hasty cleaning and rearranging of the furniture should be permitted in the room where an operation is to take place.

8. All wounds other than those inflicted by the surgeon's knife in the course of an operation must be regarded as infected by micro-organisms, and therefore need careful cleansing. Should there be any suspicion of fouling with road dirt or soil, antitoxic sera should be administered as a routine against tetanus and gas gangrene (Chapter VI.).

STERILISATION

Heat is by far the most efficient sterilising agent at our command.

(1) *Moist heat* is usually employed, either in the form of (*a*) boiling water or (*b*) of steam circulating under pressure, as this is more efficient than (2) *dry heat*, which can be used in the form of (*a*) an actual fire flame, (*b*) the cautery, or (*c*) an oven.

Sterilisation by steam circulating under pressure is best carried out in a double-jacket steriliser, such as that of Schimmelbush, or some modification of the Washington-Lyons apparatus; these need to be placed in a special chamber and carefully tended. Dressings, overalls, and other appliances not damaged by steam are loosely packed in drums or tins and covered with a layer of wool, the lid being left open. The steriliser is then closed and a 10-inch vacuum established to exhaust air from the dressings, etc., and so enable the steam to penetrate; in ten minutes steam under 15 lbs. pressure is admitted, and kept circulating for twenty minutes, when it is shut off and a 15-inch vacuum established to dry the steam from the dressings, and maintained for twenty minutes, when the steriliser is opened and the tins removed, closed, and sealed. Leather must never be placed in steam sterilisers, as it is thereby destroyed.

FIG. 3. Steam Steriliser—front removed to show dressings *in situ*.

Boiling in water or oil is carried out in some form of fish-kettle steriliser, the instruments or ligatures to be boiled being contained in a wire tray which can be lifted out. The steriliser lid must be closed during boiling, which should last for from five to fifteen minutes, the water boiling actively, and even this is not sufficient to kill all spores of bacteria, such as anthrax, *B. welchii*, etc. Rubber materials may be boiled, but care must be taken that instruments are not boiled at the same time as gloves, as these tend to be perforated or torn.

Gum-elastic instruments, catgut and kangaroo tendon are destroyed by boiling.

Flaming is an efficient but costly method of sterilising bowls or cutting instruments, which must be held in forceps, dipped in alcohol or ether, and then fired. Care must be taken not to ignite surrounding dressings or objects, and not to fire the reservoir of alcohol or ether, which must be covered before the flaming is attempted.

The actual cautery or **diathermy cautery** is sometimes used, as in cutting across bowel, to secure a sterile surface beyond the clamps, or to ensure hæmostasis.

These agents will be employed in every case possible, and, if efficient methods are used, are absolutely safe to destroy all micro-organisms, but it must be understood clearly that *unless things so sterilised are subsequently protected*, as by inclusion in a hermetically sealed tin, *reinfection will occur.*

There are, unfortunately, certain substances, such as the human body and ligatures derived from animal sources, such as catgut, kangaroo tendon, etc., which are destroyed by heat at a sufficient temperature to ensure sterilisation, and one is therefore forced to rely on other and less efficient methods for the removal of micro-organisms from the skin of the patient and surgeon, and from animal ligatures; here, indeed, antiseptics must be employed for this purpose, which in the case of the skin are ably aided by the mechanical removal caused by washing, especially if this is carried out under running water.

The various methods of sterilisation by heat and the antiseptic lotions in common use have been described, and need no further discussion here, but it is proposed to indicate briefly how the elimination of the various sources of infection in the operating theatre is carried out.

1. **The surgeon's and assistant's hands and arms** need careful attention at all times, and not only just prior to operations. In this respect always *remember never to touch pus with ungloved fingers* and to remove all dressings with forceps. The skin must be kept smooth and occupations which lead to cracking and fissuring of the epidermis avoided; especial attention must be paid to the nails, which need regular paring and cleaning. The hair should be kept short and covered with *a sterile linen cap* during operations. The teeth need regular attention, but the elaborate oral toilette performed by some Continental surgeons before operations is unnecessary. During operations and dressing of wounds *a thick gauze veil should be worn* over the mouth and nose to prevent drops of saliva falling on the operation area.

The outer clothing of the surgeon and his assistants should be removed before entering the operating theatre, and may with advantage be replaced by light overalls of duck, or by flannels, kept in the theatre and washed frequently. In many cases, however, the surgeon contents himself with removing coat and waistcoat. It is advisable to cover the clothing with a clean mackintosh or rubber apron to prevent soiling with blood or fluid while operating. The feet should be encased in goloshes or rubber boots.

Before operating and after washing, the surgeon dons a sterilised linen overall, which covers all clothing and may have long sleeves, which are tucked into the gloves, or short ones coming to the elbow. In either case the hands should be washed again before putting on the gloves, and it is wise to regard the overall as surgically unclean once it has been donned, as it touches the tables, sinks, etc., and this may escape notice, as it fits loosely. This gown should be changed between each operation.

Immediately prior to an operation some surgeons take a complete bath, but this is hardly necessary, and most are content to wash the hands and forearms thoroughly in soap and running water for at least five minutes, special care being given to the folds around the nails. The soap should be applied to the almost dry skin and worked up into a lather, and then washed off, this process being frequently repeated. Many surgeons then immerse the hands in a solution of antiseptic, such as biniodide of mercury or spirit, but we do not consider this necessary if the washing has been adequate, as the soap is a good antiseptic and, moreover, does not roughen the skin like most antiseptic solutions. After this, *sterile rubber gloves* should be put on; these may be "wet," *i.e.*, sterilised by boiling in water, or, better, "dry," sterilised by steam; in either case they should be worn as a routine for every operation, and also for dressing all septic cases. In donning them great care should be taken never to smooth down one glove with the bare hand before both have been put on, otherwise organisms may be carried to the outside of the glove by the bare skin of the other hand. Should "wet" gloves be used, care must be taken that water from the inside does not run over the glove as it is being put on, and a strip of sterile muslin should be applied to the wrist around or inside the cuff of the glove to prevent water from inside, which will contain organisms from the skin, being squeezed out during the conduct of the operation.

2. **Ligatures and sutures** fall into two classes: (1) the **absorbable** animal tissues, of which the chief is catgut; (2) **non-absorbable** silk, thread, wire, etc., and although the former are more desirable, yet as they cannot be sterilised by boiling many surgeons prefer to use the latter varieties of ligature.

The ideal ligature should be (1) absolutely sterilisable, and yet (2) remain strong and flexible, (3) be absorbable if possible, so as to avoid irritation in the tissues, but not before its purpose is fulfilled.

Preparation of Ligatures, etc. **Silk.** The raw silk is first wound on sponges, then stained the appropriate colour, and finally sterilised in the high pressure steriliser. After sterilisation it is transferred from the sponges to reels, boiled for five minutes, and then placed in spirit or 1–20 carbolic in which it is stored. It is doubtful whether spores in silk or thread can be killed by prolonged boiling. Care must be taken that the edges of ligature jars are protected by a sterile towel or boiled metal collar.

Thread is prepared in the same manner as silk.

Horsehair is washed in soap and water, boiled for three minutes, and kept in 1–20 carbolic for two weeks before using.

Silkworm gut and Japanese Salmon gut (which is prepared from the fibres of certain seaweeds) are boiled for five minutes and kept in 1–20 carbolic or spirit; the finer varieties may be boiled for three minutes.

Catgut. (*a*) *Iodised Catgut.* The raw catgut should be soaked in ether for forty-eight hours to remove the fat. It is then loosely wound on slats and immersed in iodine solution (1 per cent. iodine and 1 per cent. potassium iodide in water) for eight days, when it is ready for use. Any catgut left over after a case must be thrown away and the slats boiled. It must on no account be replaced in the iodine solution.

(*b*) *Iodised Sulphochromic Catgut.* This is immersed in iodine solution for eight days as above, after hardening in sulphochromic acid for the required period.

(*c*) *Van Horn's Catgut.* The sealed glass tubes can be boiled for five minutes before use, and may be broken open on the instrument table when required.

(*d*) *Luken's Catgut* (simple, iodised or tanned). The sealed glass tubes are soaked in spirit or 1–20 carbolic for thirty minutes before use.

(*e*) *London Hospital Catgut* (plain or chromic). This is immersed in iodine solution for eight days as above.

Gold leaf can be boiled gently for five minutes.

Kangaroo tendon is used in the same way as Luken's catgut.

3. **Sterilisation of Instruments.** All blunt metal instruments should be sterilised by boiling for at least five minutes in water to which 1 per cent. sodium bicarbonate has been added. This serves the purpose of removing grease, stopping discoloration, and raising the temperature of the boiling water about 5° C. (*i.e.*, to 105° C.). The instruments are then cooled and placed on a sterile cloth or in a tray of sterile saline on the instrument table.

Cutting instruments may best be sterilised by being wrapped in gauze and boiled for one minute, and subsequently immersed in spirit for twenty minutes before use. Some surgeons, however, prefer keeping scalpels in spirit, pure lysol or carbolic for at least twenty-four hours before use instead of boiling. Rubber tubing and catheters, glass tubing, nozzles, syringes, etc., should be boiled for five minutes. If they are required to be kept sterile for a long period, they can, after boiling, be put in 1–100 formalin, 1–20 carbolic, or lysol-ether solution, but need well washing in sterile water before use.

Cystoscopes and ordinary gum-elastic instruments (catheters and bougies) must be washed carefully in soap and water, thoroughly rinsed, then washed with methylated spirit and finally dried. Before use they are sterilised best in the formalin-vapour steriliser or by immersion in methylated spirit or 1 in 20 carbolic for thirty minutes.

Grey gum-elastic catheters (ureteric or urethral) may be boiled for three minutes in long muslin bags, with a separate compartment for each catheter. The catheters must on no account come into contact with each other or with the steriliser when being boiled. After use they are washed under a powerful stream of hot water, syringed out with spirit, and then dried.

Radium must not be boiled ; the filter or outer tube can be boiled for five minutes. Certain varieties of radium needles are boilable.

A useful *sterilising solution* in which to keep needles, cutting instruments (and other instruments for emergency use), and which neither rusts nor blunts them, is

℞ Lysol . . . . ℥i.
Surgical Spirit . . . . . . Oi.

Immersion for at least half an hour is necessary to ensure sterilisation.

In instances where instruments have been used for cases such as *anthrax*, *tetanus*, or *gas gangrene*, where the causative micro-organism is spore-forming, all instruments need sterilising in the high-pressure steam apparatus ; dressings, ligatures, etc., should be burned.

4. **Bowls and basins** should be sterilised in the steam apparatus or boiled. If this is not practicable, they may be " flamed " by washing the inside with spirit and " firing " it. This method is not, however, so safe and satisfactory. In handling basins the thumb and fingers must never be allowed to be inside, the basin being supported on the open hand. **Tables, sinks, etc.,** should be washed over with spirit or 1–20 carbolic before operation. **Overalls, towels, dressings, swabs, etc.,** should be packed lightly in tins and sterilised for twenty minutes by steam pressure, dried in vacuo and then sealed up. Dressings and swabs should consist of wool and gauze, and are best destroyed after use,

unless reasons of economy demand otherwise, when they are washed and re-sterilised. If this is impracticable boiling may be resorted to, and the towels or dressings used wet, care being taken not to scald the patient.

Marine sponges are not often employed, but if used should be washed in ether soap and water, then immersed for twelve hours in sulphurous acid, 1 part to 10 of water and then washed in sterile water.

PREPARATION OF THE PATIENT

The patient should enter the institution at least twenty-four hours before operation, when possible, so as to become accustomed to the surroundings, routine, etc. Previously to this the teeth should have been put in order and the bowels well regulated. In cases where special feeding apparatus is to be used after operation, as in tongue cases, the patient should be practised in its use.

The diet should be light, but except in cases of operation on the rectum *no* special purgation or enemata are necessary provided the bowels are acting regularly. Large amounts of sugar are advantageous before an operation.

It is essential to explain to the patient the nature and results of the intended operation, but at the same time not unduly to alarm him or to make him regard the operation as anything but a stage in the treatment of his disease. It is very necessary to secure a good night immediately preceding operation, and should the patient be nervous or wakeful a sleeping draught should be given, or morphia may be administered.

The *operation area* should be shaved on admission, and the patient take a bath then and on the morning of operation. The skin in the area is prepared both on the morning of operation and again in the theatre by one of the following methods :—

1. Washing with soap and water for five minutes on both occasions.

2. Washing with soap and water on the first occasion, and applying ether or spirit to the dry skin in the theatre.

3. Painting the dry skin on both occasions with either 2 per cent. iodine in rectified spirit or 1 per cent. picric acid in spirit. Some surgeons prefer plain spirit to which methylene blue is added as a colouring agent, to demark the cleaned area, while others use brilliant green 1 per cent. alcoholic solution, or ether. Between the first and second occasions the area is in all cases covered with a sterile dressing.

The patient may be given an injection of atropin sulphate, gr. $\frac{1}{100}$, or this combined with morphia, gr. $\frac{1}{4}$, and scopolamine, gr. $\frac{1}{200}$, half an hour before operation ; he should be conveyed to the theatre warmly wrapped and be anæsthetised outside the actual operating room. In the theatre the blankets should be removed and warmed bath towelling substituted as a covering to maintain body warmth. The operation area is exposed, packed around with sterile mackintoshes, cleaned, and the whole covered with sterile towels.

It is out of place to discuss *operative procedure* here, but a few essential points may be mentioned.

1. Make an adequate skin incision, and cut cleanly and boldly, keeping the incision to its full length throughout its depth. Never scratch and tear, for this causes damage to tissue and increases its liability to infection. Remember that there are three kinds of operators : slashers, scratchers, and surgeons.

2. Secure adequate hæmostasis and disarrange tissues as little as possible.

3. Protect exposed tissues by enveloping them in gauze soaked in warm saline, and by covering exposed skin by clipping towels to the wound edges.

4. Don't put your fingers or hands into the wound ; use forceps and retractors.

5. Close the wound up carefully by one of the methods indicated in Chapter IV., p. 44, remembering that it is essential to approximate the deeper tissues in order to prevent hæmatomata and subsequent stretching of the scar.

AFTER-TREATMENT OF OPERATION CASES

The patient should be covered up warmly and conveyed back to a warm bed, care being taken to protect him from draughts by covering the head during transit from the theatre to the ward in order to lessen the chances of post-anæsthetic pulmonary troubles.

It is often advisable to administer morphia, gr. ¼, at once in order to combat collapse, or because it is desirable to keep the patient quiet until the effects of the anæsthetic have passed off.

A careful watch must be kept to see that the patient does not swallow his tongue, or do himself any harm by flinging himself about, and that he does not choke or befoul himself if he vomits.

It is important to reassure the patient as soon as he is even semi-conscious, and, in order to secure the rest and tranquillity of mind which are essential, morphia may be given freely for the first twenty-four hours.

All wounds should be re-dressed at the end of twenty-four hours, as there is usually a slight oozing and, apart from the caked blood clot being a source of discomfort to the patient, it is an excellent pabulum for the growth of skin bacteria.

If the wound is clean it needs no further dressing until the metal clips (fourth day) or stitches (eighth day) are removed, unless a rising temperature or pain suggest suppuration, which is usually manifest on the third or fourth day after operation, but may be delayed as late as the tenth in cases of deep suppuration.

Where a drainage tube is present daily dressings are necessary, which continue till the tube is removed, usually on the second or third day after operation. Discharging wounds may need dressing several times in the twenty-four hours.

After removal of stitches or clips, wounds, if healed, need no protection, and, indeed, some surgeons do not apply any dressing after operation other than a piece of gauze laid over the wound. Hernia wounds and similar clean cases do well under this treatment, but they lack the support which a firm bandage, elastoplast or strapping gives.

The patient should be encouraged to move about in bed and do as much for himself as possible from the time he recovers from the anæsthetic, as this, besides impressing the patient with his recovery, keeps his muscles in tone and may prevent complications, such as pulmonary embolus. Ordinary straightforward cases, such as herniæ in young people and quiescent appendices, should be allowed out of bed as soon as possible, usually when the clips or stitches have been removed, although as a general rule abdominal cases are kept in bed quite ten days; but patients after operations on the mouth, face, and breast are got out of bed within three days or so of operation.

Some surgeons prefer a more cautious convalescence, as they consider the patient recovers better from the nervous shock of the operation if kept in bed for a more prolonged period.

The diet of a patient after operation should be light, but consist of dry and solid food as well as liquids, large quantities of which produce nausea and flatulence and tend to make the patient vomit and suffer from abdominal discomfort. There is no need to withhold food in the days immediately succeeding operation if the patient desires it, but in cases of operation on the stomach or upper part of jejunum this must be selected judiciously and given in small quantities.

As a general rule the diet for the first twenty-four hours after operation should consist of tea, lemonade, Bovril or any other fluid fancied (but large amounts of aerated waters and milk are to be avoided as causing distension), and biscuits, toast, jellies, etc. After this the diet can be increased in any way the patient fancies, up to fish and chicken ; large quantities of green vegetables and pastry should be avoided, especially in cases of abdominal operations. Meat may be eaten at the end of a week. Alcohol should be given to old people and those accustomed to its daily use.

After an operation such as a *gastro-enterostomy*, the diet for the first twenty-four hours should consist of sips of water, diluted tea or black coffee, jelly and Bovril or clear soup (milk should be avoided for the first three or four days, as it forms septic clots on and around the operation site).

On the second and third days the diet may be increased by adding biscuits, toast, lightly-boiled eggs, etc., which must be thoroughly chewed up.

On the fourth day boiled and fried fish and boiled potato may be partaken of, and milk may be given if desired.

On the sixth day chicken, and on the tenth day mutton, may be taken, and ordinary diet, carefully masticated, thereafter resumed with perfect comfort and safety to the patient.

The *bowels* should be opened on the second or third night after operation by the administration of a brisk purge, such as Mist. Sennæ Co. ℥i, Cascara Evacuant ʒii or Ol. Ric. ℥ss or ℥i, except in the case of :—

1. *Acute inflammation of the intestinal tract*, when purgation should be avoided for as long as a week, especially if peritonitis is present. In these cases distension may be controlled by injections of pituitrin, ½ to 1 c.c., given once or twice a day ; injections of eserine sulphate, gr. $\frac{1}{70}$ to $\frac{1}{100}$ six-hourly or acetyl-choline ½ to 1 c.c. four-hourly, will also help. Turpentine and ox bile enemata are useful (see Vol. II., Chapter XVI.)

2. *Rectal cases*, *e.g.*, hæmorrhoids, when a purge should be given the night following operation.

3. *Gastric and duodenal cases*, where enemata are preferable for the first four or five days, if the bowels are not open naturally.

Post-anæsthetic vomiting (see Vol. I., Chapter XXIV.) is an all too frequent sequel to operations, but can hardly be called a complication and usually ceases after the first twelve hours. Should it persist, however, it may cause inconvenience, and often can be cured by the administration of a drink of warm water containing a tablespoonful of sodium bicarbonate, which dissolves the mucus in the stomach ; this is returned, but leaves a clean and quiescent stomach. It must not be forgotten that a full rectum or bladder may much increase the tendency to vomit. In extreme cases gastric lavage should be resorted to, while Tr. Iodi, ♏i, or cocaine, gr. ss, by the mouth often will help.

Vomiting is far more liable to occur after a prolonged or unskilful anæsthetic, and in a nervous or frightened patient. Prolonged starvation before anæsthesia should be avoided as likely to cause acidosis and therefore aggravate any tendency to post-anæsthetic vomiting, which in these cases should be treated by drinks or infusion containing sodium bicarbonate and glucose.

In cases where vomiting has caused acidosis and a vicious circle become established, as may occur in any persistent vomiting, relief can be obtained often by giving an injection of 10 units of insulin combined with barley sugar *ad lib.* to suck, while in more severe cases intravenous infusion of 20 units of insulin in ℥x of 50 per cent. glucose solution and ℥x normal saline is very efficacious.

In neurotic subjects, who in many cases are determined before anæsthesia that they will be sick, every care must be taken to correct their mental outlook, and if vomiting persists absolute cessation of all oral feeding, not even allowing water to wash out the mouth, with administration of rectal salines four hourly, is always productive of a cure. Such treatment can be kept up for forty-eight hours and be repeated if necessary.

In any case of post-anæsthetic vomiting care must be taken not to alarm the patient and to re-establish confidence, while the practitioner must remember that a light dry diet is less likely to produce abdominal discomfort and vomiting than a long course of "slops." In cases where such diseases as peritonitis or uræmia are present, it must be realised that persistent vomiting after an operation is more likely to be due to these conditions than to the anæsthetic.

POST-OPERATIVE COMPLICATIONS

These fall into two classes: (A) The Immediate; (B) The Remote.

(A) The *immediate complications* may occur during or within an hour or so after operation.

(1) **Cardiac failure and respiratory failure** may occur in the early stages of the induction of anæsthesia, when they are the result of sudden shock, or during or immediately following operation, usually as a sign of collapse, and call for prompt measures. Care should be taken that no foreign body, such as a denture, or vomited matter, is obstructing the patient's airway. These conditions, if due to anæsthesia, in which case their onset is sudden, fall to the lot of the anæsthetist to treat, and are dealt with in Vol. I., Chapter XXIV., but they may also come on gradually as the result of "*collapse*" induced by prolonged exposure or handling during an operation; the treatment in this case consists in finishing the operation as rapidly as possible, keeping the patient warm, and administering morphia, gr. ¼–⅓, hypodermically, which is a most valuable drug in this condition, especially if the pulse is irregular. As a general rule stimulants, especially strychnine and pituitrin, should be avoided, on the principle of "not flogging a tired horse" (Chapter IV., p. 53). The foot of the patient's bed should be raised, and in extreme cases the application to the head of cloths wrung out from boiling water may have an almost miraculous effect as a resuscitant. For the same reason saline infusion should be avoided in these cases of post-operative collapse, for as the circulation is feeble the tissues easily become water-logged, and œdema of the lungs is a not uncommon and fatal result if infusions are given. Where, however, much blood has been lost, not more than a pint of fluid, to which ℥i of brandy and ʒi of soda bicarbonate can be added, may be introduced into a vein, but even in this case gum solution, because of its greater cohesiveness, is preferable to saline. Blood transfusion is not usually practicable, owing to the urgency of the conditions, but, if possible, can be practised with advantage.

(2) **Retention of urine,** especially after pelvic operations, may be a difficult matter, but usually the patient will void urine following the oral administration of urotropin, grs. x, or Ac. Boric. ʒii in ℥i of water, or an injection of doryl or pituitrin, 1 c.c. Hot bottles to the hypogastrium and to

the feet will help. The administration of an enema also may have the desired result. If practicable, the patient may sit on the side of the bed or even stand up when micturition is usually prompt and easy, but if this is not permissible, catheterisation may have to be resorted to; this is, however, rarely the case.

Hysterical retention in women should not be treated by catheterisation, as such patients always will void urine when they are really uncomfortable. In this respect it always must be remembered that cases reported not to have passed water frequently have done so into the bed-pan when the bowels have been opened, in which case they are comfortable and the bladder not distended. In a few cases, especially after kidney, prostate or bladder operations, no urine may be passed as a result of "suppression," a condition which needs prompt handling in order to prevent uræmia. Hot enemata and copious drinks are usually efficient, but in severe cases more drastic measures may be necessary, such as hot packs, the administration of theobromine or sodium-thio-sulphate or sodium-thiocine-acetate.

(3) **Uræmia** may develop any time after operations on the urinary tract or in patients suffering from renal disease. Usually it is preceded by suppression, but sometimes large quantities of urine deficient in urea may be excreted. The blood-urea is high, the patient is usually drowsy or comatose, the skin dry, the tongue furred and the bowels costive; abdominal pain and distension are not uncommon, and twitching of muscles and convulsions usually herald a fatal result. The treatment is that of uræmia in general (see Vol. II., Chapter XX.).

(4) **Hæmorrhage** may occur during the first forty-eight hours after an operation from the slipping of a ligature, and is then known as "reactionary" (see p. 51): it must be promptly dealt with by taking the case back to the theatre, opening the wound and securing and ligaturing the bleeding point, after which morphia and, if necessary, saline may be given. Recognition is easy if the case is one of external hæmorrhage, though if "internal," as may occur after abdominal, pile or chest operations, the condition may be confused with "post-operative collapse"; but in hæmorrhage the pulse gets more rapid, restlessness and air-hunger develop, and the abdomen, if containing blood, becomes acutely tender on pressure, and may show shifting dulness.

(5) **Sleeplessness** may be troublesome, especially in nervous patients, and can often be cured by hot milk or whisky, but should this fail hypnotics, such as aspirin and bromide, nepenthe or medinal, may be necessary. A vast selection of good hypnotics is available.

(B) *Delayed Complications.*

(1) **Acute dilatation of the stomach** is a rare but usually fatal complication which may occur within the first few days after operation. The patient becomes acutely ill, collapsed, and vomits frequently and copiously; he frequently smells of acetone, and later becomes drowsy and dies in coma. Jaundice may supervene rarely. The stomach can be shown to be enormously dilated, it may contain over a gallon, and is atonic. Treatment consists in early recognition and gastric lavage. Placing the patient prone on his face is often useful (see Vol. II., Chapter XV.).

(2) Another rare complication is **delayed chloroform poisoning**, a condition closely analogous to acute yellow atrophy of the liver, which is small and fatty, and on microscopy shows acute necrosis of its cells. The patient, usually about ten days after operation, becomes delirious, and later comatose,

vomits and shows signs of intense jaundice; death rapidly supervenes. These two conditions are now very rarely seen, probably more by reason of the abandonment of pre-operative starvation and purgation than from the lessened use of chloroform as an anæsthetic.

(3) **Uræmia** may be a late complication, but has been mentioned already.

(4) **Secondary hæmorrhage** may occur in septic wounds, usually about the tenth day after operation, and is often preceded by a slight initial hæmorrhage which occurs a few hours before the main bleeding. In cases where it is suspected, a close watch must be kept on the wound and pulse of the patient, and in cases of limb wounds a tourniquet kept over the bed. The condition will be dealt with fully in Chapter IV., p. 51.

(5) **Pulmonary embolism or thrombosis** (p. 260), the ætiology of which is unknown, is an increasingly common and very often fatal complication, which may occur any time from the fourth to the fourteenth day after operation, usually about the tenth day. It may follow the most trivial operation, but is commoner after operations on the upper abdomen, and seems to be predisposed to by the presence of sepsis in the wound, or by the co-existence of pulmonary complications, such as post-anæsthetic bronchitis or massive collapse. Patients kept very still in bed after operation appear to be more liable to the condition. Post-mortem, one or more branches of the pulmonary arteries, and maybe the main vessel and right ventricle, are found choked with clot, which may have formed as a result of ante- or post-mortem thrombosis; this clot spreads along the radicles of the pulmonary artery far into the lungs, but seldom yields any positive cultural result as regards bacteriology. Many pathologists regard the condition as one of thrombosis in the peripheral vessels of the pulmonary circulation, the clot spreading back to the great vessels and then suddenly increasing and impeding the heart's action. Certainly there is evidence that the older clot is usually at the periphery. The condition takes some time to develop after operation, and is less likely to occur if the patient moves about and breathes deeply. It is, however, difficult to explain the sudden onset of pain and dyspnœa on this hypothesis.

The signs are a sudden pain in the chest, with inability to breathe, the patient becoming first cyanosed and then ashy-grey and frequently dying at once. In some cases just before the onset the patient feels an intense desire to pass a stool; in less severe cases death may occur in a few minutes, but if the initial attack passes, the prognosis is good and recovery usually results, patients frequently thinking they have had a very severe attack of indigestion. Second, or even third, attacks may occur after a few hours' or days' interval, but these are most uncommon, usually less severe and rarely fatal. In these slighter attacks, hæmoptysis and the signs of consolidation with a dry pleurisy will be noticed. Thrombosis of deep veins, such as the femoral, not infrequently follows in a few days' time.

Treatment consists in the immediate injection of morphia gr. $\frac{1}{4}$–$\frac{1}{3}$ combined with atropine sulph. gr. $\frac{1}{100}$, and the administration of oxygen, and in reassuring the patient that the worst is over. Subsequently rest in bed for some days is necessary, as friction-rub and expectoration usually manifest themselves in the course of a day or so after the attack. (For Trendelenburg's operation see Vol. II., Chapter XI.)

(6) **Massive pulmonary collapse** is an uncommon complication, and usually follows operations on the upper abdomen. The patient, usually the day after operation, complains of discomfort and tightness in the chest and upper

abdomen; an examination shows the lower part of the chest on the affected side to be moving badly, and auscultation reveals deficient air entry to the lower lobe. The temperature is sometimes high for a few days. An X-ray film shows the diaphragm to be raised and motionless. The condition may clear up in a day or two, or may be the precursor of other pulmonary affections or subphrenic abscess. Treatment consists in giving CO_2 inhalations, in applying a blister in the neck, to counter-irritate the phrenic nerve, and giving an expectorant mixture. Inhalations of CO_2 at the end of operation are a valuable prophylactic and may be repeated with advantage the day following operation in cases where pulmonary complications may occur (operations on the upper abdomen), and if such complications do occur.

(7) **Thrombosis of veins** usually follows operations only when infection is present in the wound. It may affect any vein, though the left femoral is most frequently affected, and the process is probably of the same nature as pulmonary "embolus." The affected part becomes swollen and tender, the vein may be seen or felt as a hard cord, and œdema can be demonstrated in the tissues distal to the affected part.

Treatment consists in keeping the patient in bed for at least three weeks, with the limb supported on pillows or in a cradle. After this time massage may be given gently for a week, and then the limb gradually brought into use. If the clots are infected they tend to disseminate and give rise to **pyæmic abscesses,** especially in joints and the lungs, a condition indicated by the appearance of painful inflammatory swellings or a friction rub with signs of broncho-pneumonia following on a rigor: in the case of abdominal wounds, hepatic abscesses develop from **portal pyæmia**; these may be many in number, in which case the patient becomes slightly jaundiced and the liver enlarged and tender, rigors are frequent; death supervenes rapidly in these cases of suppurative pylephlebitis (p. 283).

Chronic pyæmia may be a troublesome sequel in non-fatal cases.

(8) **Septicæmia** may supervene, especially where bone or joint operation wounds become infected.

These conditions are fully dealt with in Chapter V., p. 75, but it is perhaps well to draw attention to the necessity of opening and freely draining the infected wound.

(9) **Post-anæsthetic bronchitis and broncho-pneumonia** are dealt with in Chapter XXIV.

(10) **Delirium tremens** is a condition sometimes seen after operations, and also commonly in patients with fractures or other accidental injuries. It occurs in chronic alcoholics, usually as a result of deprivation of alcohol, and manifests itself three or four days after admission. The patient is usually morose and suspicious, and towards night becomes very wakeful and prone to hallucinations, to see "things," or hear persons conversing. If untreated, these get worse and the patient will rise from bed to remove imaginary objects, or to escape from animals or enemies; during the day there is mental depression, delusions, loss of appetite, a furred tongue and constipation.

Treatment consists essentially in prophylaxis—by administering alcohol in small doses to chronic alcoholics from the day of admission and keeping the bowels moving freely. Once the condition has developed alcohol should be given, and strong purgatives administered to open the bowels, which are usually very obstinately costive in spite of treatment. The patient needs reassuring, and gently and tactfully restraining from leaving the bed—violent restraint only aggravates him; sedatives, of which the best is Inj. Hyoscine, gr. $\frac{1}{100}$, combined with morphia, gr. $\frac{1}{4}$, should be given. Large doses of chloral and bromide are useful.

(11) **Post-operative mania** is a rare but frequently fatal complication usually seen in pregnant or neurotic women and following operations on the pelvic organs; it, however, rarely may occur in men, and Jews seem particularly liable to it. The patient develops acute mania, usually with suicidal tendencies, and needs immediate isolation and constant watching and care, if possible in a mental institution.

(12) **Post-operative hiccough** is an irritating phenomenon seen sometimes after abdominal operations, when it may persist for several days. In some instances it is of serious import implying the onset of uræmia or peritonitis, in which case other signs of these conditions will be present including a dry tongue. More often it is a distressing phenomenon and ceases during sleep, in which case it is best treated by reassuring the patient, and giving small doses of cocaine or morphia, while in some cases a change of position is beneficial.

CHAPTER II

INFLAMMATION

Its Relation to all Tissue Repair—Acute and Chronic Inflammation—Clinical Signs—Abnormal Repair—Scars

Inflammation may be best defined as the normal reaction of the body tissues to any irritant, be that in the form of trauma, infection or new growth. This irritation may be the result of injury, of surgical operations, of bacterial infection, or of new formations of abnormal tissue. The resulting inflammatory process called forth in the affected area is, in its initial stages, the same in every case; in the later stages local conditions, both as regards the reaction of the tissue affected and the cause calling forth this initial inflammatory reaction, may much modify or even mask the results of this common early stage.

The causes of irritation may be classified into:—

1. Mechanical. Blows, wounds, fractures, strains, etc.
2. Thermal. Burns and scalds, frost-bite.
3. Electrical. Lightning stroke, X-ray burns.
4. Chemical. The action of caustics, strong acids, etc.
5. Bacterial. Various micro-organisms.
6. Neoplasms (new growths) which cause intense reaction in the surrounding tissues.

These will be considered in detail later, as both in their physical signs and ultimate inflammatory results they differ widely in their effect on the organism; here, where only the initial stages of the common inflammatory reaction produced by all these cases are under consideration, it will be unnecessary to differentiate them. It is, however, necessary to say how very frequent and important living bacteria are as a cause of inflammation.

Clinical Signs. Celsus, writing in A.D. 50, gave as the signs of inflammation *heat*, *redness*, *swelling* and *pain*, to which classical signs should be added *loss of function*. Clinically, it is often difficult to separate the immediate signs of injury to the tissues, such as the mechanical effusion of free blood from damage to vessels in the affected area, from the early stage of the inflammatory reaction, with its passive transudation of fluid through the vessel walls.

Both these conditions give rise to a certain amount of swelling in the region, which may be very considerable in areas where the connective tissue stroma is lax, *i.e.*, the scrotum and eyelids. Inasmuch as this swelling is due to fluid lying free among the tissue cells, the area is found to be boggy to the feel and to retain the impress of the examining finger, *i.e.*, to pit on pressure, signs denoting a condition of *œdema*.

The inflamed area in addition will be found to look red, as compared with the surrounding parts, and to feel hot, both conditions being due to the increased blood supply consequent on the inflammatory reaction.

Owing to pressure of fluid on nerve endings the area is painful and tender, and for this reason, from the effect of the exudation on muscles and nerves, the movement of the part will increase this pain, and the affected region is kept still by the patient—*i.e.*, there is loss of function.

Pathology. Turning to the micro-pathology of this condition, a subject best studied by examining the behaviour of the tissues of a translucent area, such as the web of a frog's foot, to which an irritant has been applied, it will be found that the sequence of events observed is the same whatever irritant is employed—that is to say, the inflammatory reaction of the tissues is the same to a cut as to a bacterial infection. The first change observed is a *dilation of the blood vessels in the tissues* around the source of irritation, with an *acceleration of the blood stream.* This increased rate of blood flow is, however, only very transitory, and is succeeded by a gradually *increasing slowing of the blood stream,* which may proceed to actual stoppage, with subsequent thrombosis of the vessel.

At the same time a change can be observed in the blood; the red corpuscles, as a result of the slowing of the blood stream, tend to accumulate in rouleaux in the centres of the vessels, while the white corpuscles adhere to the endothelium, and later can be seen passing through the vessel wall in large numbers (*diapedesis*) and lying among the surrounding tissue cells. This change is most marked in the immediate vicinity of the irritant, and is much more obvious in cases of bacterial infection than in other cases.

The exact mechanism by which this exudation of leucocytes occurs is not known, but it probably takes place between the endothelial cells as a result of disintegration of the cement substance—certainly red cells and plasma escape also, showing there is leakage through the vessel wall. As soon as thrombosis occurs, exudation from that area ceases.

It is of great interest to note that in acute inflammatory conditions the common type of white cell is the polymorphonuclear leucocyte, which is exuded in numbers far in excess of that found in the blood stream, whereas in chronic inflammation the predominant white cell is the small lymphocyte.

Turning now to the changes in the tissues around, it can be seen that there is an accumulation of fluid between the cells; this is derived mainly from the vessels, and may in some cases, as in the blisters from burns, be so excessive as to separate the cells and disintegrate the tissues, a condition known as *colliquative necrosis.* This fluid can be shown to be rich in various antibodies (p. 35), and plays an important part in tissue repair.

The red cells after transudation are rapidly broken up and their pigment reabsorbed, though it frequently causes discoloration in the area during the process.

The white cells may return to the vessels, but more frequently actively migrate, by diapedesis, towards the source of irritation, being apparently actively attracted to this region (positive chemiotaxis), though in some few cases they will be found to be repelled from the irritant (negative chemiotaxis). The white cells and plasma are to be regarded, therefore, as the tissues' first line of defence. They are accumulated in great numbers around the irritant, which, under favourable circumstances, they eliminate before proceeding to restore the surrounding tissues to their normal conditions—a process known as *Resolution.*

Resolution and Repair are the most favourable results of inflammation, and usually follow after non-bacterial irritation; they are accompanied, both clinically and microscopically, by retrograde changes, with gradual return to normal conditions. Thus, clinically, the pain, tenderness and redness get less, the œdema and swelling disappear, and the affected tissue resumes its normal function, though in the case of special tissues such as bone and nerve (peripheral) it may be a considerable time before full restoration of normal tissue is complete, if indeed this ever occurs; in the case of the brain and spinal cord regeneration never occurs. Microscopically, the cells return to the vessels, the blood stream accelerates (actual thrombosis is not likely to have occurred), the plasma is absorbed and the part returns to normal. In cases where this process has taken a considerable time (chronic inflammation), there are certain permanent changes in the tissue, due to the formation of cells known as fibroblasts in and around the exudation. From these cells fibrous tissue is developed, which to a varying extent strangulates the vessels and cells of the part, with the result that it becomes distorted and more or less avascular, a condition clinically manifested by *scarring* of the tissues and thickening around the inflamed area due to formation of new tissue elements (*organisation*).

Frequently the later stages of the inflammatory process do not result in so favourable an ending as described, this depending on various factors such as the nature of the irritant applied, a bacterial infection being much less favourable to resolution than any other cause. Again, such factors as the virulence of the infection and the local resistance of the tissues must be taken into account, as is shown by the fact that different cultures of the same organism may produce different degrees of inflammation if injected into the same tissue, or that the same tissue in different individuals will give very different reactions if injected with the same culture in equal amounts.

These less favourable results of the inflammatory reaction, indicating as they do that the tissue cannot cope with the irritation produced by the poisons resulting from the bacterial infection, which is usually the *fons et origo mali* in such cases, are marked by a common stage, transitional between the early stages of normal tissue reaction just described, and the later stages where the inflammatory processes are masked and modified by the local conditions.

Clinically the earliest sign of serious trouble is that the increased redness in the area does not disappear on pressure; this can be shown to coincide with the vascular thrombosis, which naturally prevents the blood being expressed from the vessels in the area. Furthermore, there will be noticed an *increase in the œdema* and a *change in the nature of the pain* from a burning or smarting to a *throbbing character*. This indicates the onset of **suppuration** in the area, and is a sign that the local resistance of the tissues has been overcome by the infection. The tissues now call up reinforcements in an attempt to localise the infection, with the result that there is an increase in the area affected by the inflammatory process—to what extent is determined by the success or otherwise of the attempt at localisation; the greater the success the less will be the spread of the inflammation. The local clinical signs become more marked, and about this stage general or constitutional signs begin to manifest themselves, as a result of the disturbance of the organism as a whole. These are due mainly to the absorption of toxins from the inflamed area, and will be the more marked the greater the tension of the inflammatory products in the area affected; thus a small bead of pus under great tension, *i.e.*, in the tissues lining the external auditory meatus, will produce far greater constitutional signs than a large abscess in the loose cellular tissue beneath the pectoral muscles or in the scrotum, because of the toxins being more readily absorbed when under pressure.

The constitutional signs are *fever*, which is usually of the intermittent type, the temperature being at its highest about 8 p.m., and lowest, usually normal, about 8 a.m. daily; this is accompanied by a more or less *rapid heart beat, dry tongue and mouth, headache, general malaise* and *scanty high-coloured urine. Shivering* and *vomiting* may occur at the onset of the disease. There is frequently loss of appetite, and in long-standing cases muscular wasting, weakness and constipation.

It should be noted that occasionally in cases proceeding to resolution, where the inflammation is the result of trauma, and no suppuration is present, a certain amount of mild febrile disturbance may accompany healing; this is known as **aseptic traumatic fever** and is most frequent in cases where there has been considerable effusion of blood into the tissues, *i.e.*, after fractures and in wounds after operations, especially where a hæmatoma has occurred.

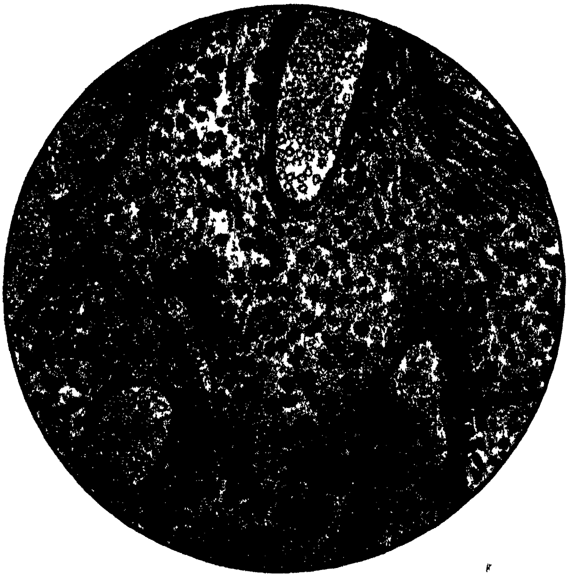


FIG. 4. Granulation Tissue from a peritoneal adhesion, showing plasma cells and fibroblasts. × 200.

It is by some regarded as due to the absorption of fibrin ferment from the clot, and by others as resulting from mild infection with the *Staphylococcus albus*, usually to be found in all such clots.

According to the success or failure of the tissues in localising the infection, one of the following results will occur:—

1. Abscess formation.
2. Cellulitis.
3. Local gangrene (death of tissue).
4. General infection of the body—septicæmia, pyæmia, sapræmia.

All of these conditions are dealt with in the chapter on Infection, as they are to be regarded rather as the sequelæ of infection than as an integral part of inflammation.

Regeneration. Normally, resolution of the inflammatory process is succeeded by a process of tissue repair (regeneration), the tissues of the part, if damaged by the irritant, being gradually restored to their normal structure; thus, after a fracture the bone becomes differentiated from the other tissues and reformed, a process which takes longer than the repair of the surrounding soft parts.

New capillary vessels are formed among the exudate, budding out from the sides of existing capillaries, and joining with other buds to form loops, around which appear fibroblasts and plasma cells. Thus there is formed a very vascular mass of soft, friable tissue, bright red in colour and bleeding easily to the touch; it is known as *granulation tissue*, and is well seen on the floor of a clean healing ulcer. In the case of an incised wound with the edges approximated, it is very small in amount, as the surrounding tissues are in contact and soon re-establish their continuity, a condition known as **healing per primam**; whereas in ulcers and lacerated wounds where much tissue is missing and a space exists filled with blood clot the replacement of this clot by granulations is a slower process (**healing by granulation**), which can sometimes be accelerated by approximating two granulating surfaces (**healing by union of granulations**), a process only to be attempted in the absence of infection of these granulating surfaces.

The *fibroblasts* are elongated cells, which throw out a series of fibrils in and around their cytoplasm which gradually elongate and narrow down the original cell, and by their contracture give firmness to the new tissue, ultimately becoming so numerous as to result in constriction of the vessels and obvious scarring in the area.

The *plasma cells*, which are irregular in shape and contain granules in the cytoplasm, are distributed among the capillaries and form a stroma, from which the tissue cells may regenerate; or perhaps they act merely as a scaffolding along which the cells of individual tissues grow out into the injured area and ultimately reform it.

This repair is brought about by changes in the scar and granulation tissue in the area, which it will be remembered consists of blood vessels, plasma cells and fibroblasts, but the regeneration of tissue is usually more or less imperfect, so that some fibrosis and scarring persists in the affected area. Usually the longer the irritation has persisted, the greater the resulting scarring; hence extensive fibrosis is more common in cases where infection has been present, or large areas of tissue have been affected or lost by sloughing

The treatment of inflammation is more aptly dealt with under the various types of inflammatory reactions called forth by different irritants in the body, but it may not be out of place briefly to enumerate here the essentials of the treatment necessary in any inflammatory reaction:—

1. *Removal of the cause of irritation* whenever practicable, or the reduction of the irritant to a minimum if its total removal is not possible. To attain this end the area may be excised or treated with the cautery or caustic; but as this in many cases entails severe damage to tissue, it is frequently advisable to content oneself with less drastic measures which aim at the removal of as much irritant as possible while not damaging the tissues more than is necessary or compatible with their subsequent utility. Such methods consist in incisions, drainage, and means to promote freer blood and lymph supply which serve to remove the source of irritation from the locality and are fully described in Chapter III., p. 27.

2. *Rest and support* to the inflamed area, in order to lessen pain and to localise infection.

3. *Promotion of increased blood and lymph supply* to the area, so as to bring reinforcements of white cells and antibodies to deal with the source of irritation. This also serves to dilute and carry away the irritant, but unless

this latter is already destroyed this process may convert a localised into a generalised infection.

4. *Maintenance of general body nourishment* by good food, fresh air and stimulants.

5. *Adequate purgation* to remove such irritant or toxins as have been excreted into the bowel or urinary system and prevent reabsorption.

AFFECTIONS OF SCARS

It is characteristic of the fibrous tissue formed in scars that it contracts—usually to about two-thirds its original length; hence the puckering and depression so frequently seen in scars, which may not occur till some time after healing has taken place, and which in some cases, *i.e.*, after extensive burns and around joints, may lead to gross *cicatricial deformities.* It is therefore necessary to take steps in all cases of extensive inflammation to prevent subsequent deformity, and this is best done by fixing the affected part in a slightly over-corrected position by suitable apparatus.

Again, the steady contraction of the fibrous tissue leads in time to the complete avascularisation of the scar, which gradually changes in colour from pink to white. The area is re-covered with epithelium, but this contains no glands or hair follicles, and is therefore smooth and shiny. Under certain conditions overgrowth of scar tissue may occur, the area appearing smooth, raised above the surface, and pale pink in colour, being firm to the touch; sometimes burning and itching sensations are complained of by the patient. This condition, which is known as a **keloid,** may occur anywhere in the body, but is common in neck wounds, especially if in the vertical direction, and is particularly likely to occur in tuberculous and chronic infective scars, as after burns and in the scars of vesicles following vaccination or acute fevers. Its ætiology is obscure, but there is no doubt that certain individuals are particularly prone to the condition, which may be due to a fibromatosis starting in the walls of the capillary vessels of the scar.

FIG. 5. Keloid in Vaccination Scars. Pigmentation due to X-ray treatment.

The treatment consists in the application of radium or X-rays in suitable doses, or in complete excision with resuture, but the results are frequently disappointing, the keloid tending to recur in the new scar.

Another abnormal condition occasionally met with in repair following on chronic inflammation, where very often a mild irritation and inflammation are still present while repair is in progress, is a *hyperplasia* of the new-formed tissue elements, leading to overgrowth of the affected part and a condition of local **gigantism.** This is sometimes seen in chronic osteitis, where overgrowth of the affected bone leads to actual lengthening of the bone, and so of the limb, and is probably due to long-continued irritation causing increased blood supply to the area.

As previously indicated, fibrosis in the scar normally leads to avascularisation. This may proceed to such a degree that the nutrition of the scar is so far impaired as to lead to its breaking down, a process of *ulceration* resulting (Chapter VII., p. 143) from molecular death of the epithelium. Such scars with ulcerative changes are common in areas with deep fibrosis and a poor blood supply to the part, such as old-standing varicose ulcers in the leg; the condition is very intractable, but the best treatment is complete excision of the scar, where possible, with resuture of the wound. Where this is impossible, owing to the nature and size of the scar, X-rays or ultra-violet rays may prove of benefit by stimulating epithelial growth, or some method of inducing passive congestion, such as Klapp's suction bell or Esmarch's bandage, may be tried. It is recommended by some authorities that deep incisions be made into and around the scar, but this is nearly always followed by extensive necrosis.

Similarly, the fibrous tissue by pressure on nerves in the area may cause a *painful scar*, the pain being either localised in the scar, which may be tender to the touch, or referred to some other region supplied by the nerve. Treatment of this distressing condition consists in irradiation with X-rays, excision of the scar and freeing of the nerve, or excision alone in the case of small filaments only being involved, but the resulting wound is again apt to cause further trouble on healing. Injection of absolute alcohol into the nerve may be tried if excision is impracticable.

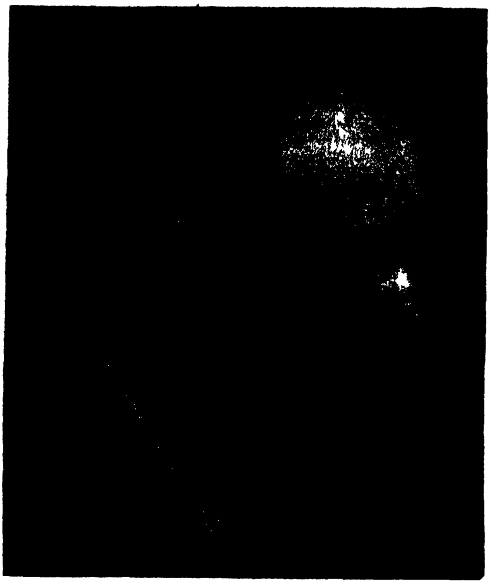


FIG. 6. Squamous-celled carcinoma (ulcerated) in an old burn scar.

Malignant disease. Tumours—carcinoma or sarcoma—may occur in old-standing scars, especially if they are chronically ulcerated and infected, as after burns and lupus. Treatment consists in free excision of the whole area as soon as the condition is diagnosed and confirmed by microscopy, or if the area is very extensive and in a limb, this may be amputated. Radium gives good immediate results in these cases.

CHAPTER III

INFECTION—SUPPURATION—BACTERIOLOGY OF SURGICAL DISEASES—IMMUNITY

Infection. Infection is the term applied to the invasion of the body tissues by micro-organisms, and is frequently also used to include the inflammatory phenomena which are the natural sequelæ to the irritation of the tissues by these organisms or the poisons (toxins) resulting from their growth.

The local signs of infection in its initial stages are, therefore, those of inflammation, namely, heat, redness, swelling, pain, and loss of function, and the *pathological changes* in the tissues leading to these phenomena are those already discussed. There is, however, in these cases of infection one important factor wherein the process differs essentially from those considered in previous chapters, namely, that the source of the irritation is a living organism, or usually a series of such, and is in itself capable of very rapid multiplication and resistance to the inflammatory reaction of the tissues aimed at its destruction and elimination.

Here, then, is a complication likely, on the one hand, to intensify the local inflammation in the tissues of the infected organism, and, on the other, to lead to an extension of the process, both in severity and extent; thus, in cases where the invading organism succeeds in establishing a colony, death of the white cells endeavouring to remove these may result, or in severe cases actual death of tissue as a sequel of vascular thrombosis, and the poisonous effects of the bacterial toxins on the cells.

This mass of living and dead leucocytes, mostly polymorphonuclear, *necrotic tissue, living and dead bacteria, and serum,* forms a more or less liquid mass in the surrounding tissue, and is known as **pus**, and the processes leading to its formation as **suppuration.**

The surrounding tissues will become involved in the inflammatory process, more leucocytes and serum will be liberated in the region, and should these succeed in *localising the infective process* to the area an **abscess** will result (see p. 69). This consists of a central area of liquid pus, surrounded by a dense layer of leucocytes (*pyogenic membrane*) in the live tissues.

If, on the other hand, the organisms succeed in overcoming this further inflammatory reaction, the area of infection spreads, and consequently the inflammation extends around it into the tissues in a further endeavour to eradicate the irritant; this gives rise to a **cellulitis.**

The *clinical signs* of the onset of suppuration are a general increase of intensity in both the local and general signs of inflammation, together with a change in the type of *pain,* which *becomes throbbing* in character.

If an *abscess* forms, the red area becomes localised; at first it is brawny to the touch, but later it softens as liquefaction of the pus progresses, and œdema can be demonstrated in the area—a process brought about partly by destruction of dead leucocytes and bacteria, and partly by further exudation of serum.

At this stage *fluctuation* may be detected, this being a sure sign of the presence of a localised collection of fluid under tension in the tissues. It should be tested for by placing the ends of the index fingers of both hands on the skin of the area, firmly but gently, so as not to cause undue pain, and then pressing with one finger, when a fluid wave can be detected impinging on the other. Another method of testing for fluctuation is to place the thumb and index of one hand upon the swelling, a short distance apart, and to press with the index of the other hand between them. It must be remembered in this connection that excellent fluctuation may be obtained *across* the fibres of a normal muscle, and, indeed, a good method of accustoming oneself to the sensation of fluctuation is to apply this method across the quadriceps cruris muscles when seated.

In *cellulitis* there is a diffuse reddened area, with no definite edges, the skin over which is often semi-transparent and shiny, due to effusion of serum between the cuticle and cutis vera, or may even show black, dead patches. The area is raised and exquisitely tender. No definite fluctuation can be detected usually, but the whole area is soft and boggy to the feel. Œdema is present and may be very marked in areas where lax tissues exist, such as the scrotum, eyelids and face. Similarly, in such areas the lessened tension on the nerves gives rise to less pain, and, there being less absorption of toxins, the general signs will be less marked (see p. 71).

The treatment of the infection in the early stages consists in various methods, the aim of which is to assist the tissue reaction by increasing the blood supply to the part, and so introducing more leucocytes and antibodies to the area. It must be borne in mind, however, that these methods are not only useless in cases where suppuration has occurred, but are frequently actually harmful in allowing the pus to track along the planes of cellular tissue and so spread the infection.

Many methods are in use in the treatment of the early stages of infection; they may be divided into two classes, according as to whether they aim at increasing the blood flow to the part (*active congestion*), or at holding the blood for a longer time than normal in the inflamed area (*passive congestion*).

(*a*) The means used to produce *active congestion* are—

(1) *Heat* applied locally, either in the form of moist heat—*i.e.*, baths or hot fomentations; or dry heat—hot air baths or hot pads.

Of these two, the moist heat is probably the better method, and is certainly conducive to greater comfort and relief for the patient. The part can be soaked for long periods in a bath of hot water, renewed from time to time, or fomented by dressings of lint, soaked in boiling water and wrung out till dry, which are applied frequently under a dressing of oiled paper and wool.

In the case of inflammation of the mucous membranes of the nasal and respiratory tracts, moist heat is applied by the inhalation of vapour from hot water, to which various aromatic drugs are frequently added.

The hot air bath is most conveniently applied by means of a frame containing one or more electric bulbs, and covered with blankets.

Return of blood to the heart should be encouraged by elevating the inflamed part; this is important, as the local exudation may tend to obliterate the veins by pressure, and so aggravate the condition by the blood stagnating in the area.

(2) *Counter-irritation* is also of value, but not so much in acute as in chronic inflammation. This method of treatment is based on the assumption that stimulation of one area of a nerve's supply will cause similar changes to occur in its other supply areas, in clinical support of which is cited the reference of

pain from one to another area of nerve supply in renal and biliary colic, and in certain joint diseases, *e.g.*, pain referred to the knee in disease of the hip.

Stimulation is therefore applied to the area of skin supplied by any given nerve with the hope that this will induce vaso-motor changes in the inflamed part. Some mild irritant drug is usually painted on the skin, such as iodine or liquor epispasticus (cantharides), or oil of mustard may be employed, this usually in the form of a plaster. As a general rule, a piece about 1 inch square should be applied for about one or two hours and then removed; the skin will be found reddened, and frequently a blister is raised, which leads to the popular term "blister" being applied to the cantharides or mustard plaster.

(3) *Dry cupping* is another method by which counter-irritation and hyperæmia may be achieved, and is a method popular on the Continent in the treatment of acute lobar pneumonia.

(*b*) *Passive congestion* may be induced by any method that obstructs venous return, but inasmuch as complete arrest of the blood flow to the heart results in blood stagnation in the area, with consequent accumulation of toxins and the danger of clotting, it should never be allowed, only a partial arrest of the venous return being aimed at. This method was first advocated by *Bier*, and is usually associated with his name (*Bier's passive congestion*).

For this purpose (1) a bandage may be tied around a limb proximally to the inflamed area, and just so tight as definitely to embarrass the venous flow, which will be proved by the part distal to the bandage assuming a purple hue. In this method it is customary to use an elastic rubber bandage, such as *Martin's* or *Esmarch's*, rather than a cotton one.

(2) *Klapp's suction bells* are an ingenious device by which this method may be applied to areas where the bandage method is inapplicable, or where small areas only need treatment. They consist of glass cups of various shapes and sizes, which have a rubber ball attachment for exhausting them of air, and which are applied to the greased skin in a partly exhausted condition.

Whichever method of inducing passive congestion is employed, it should be painless; pain indicates either that the congestion is maintained too long, or that suppuration has occurred in the area. As a general rule, the method can be borne for about five minutes at first, the time being gradually increased at each application up to about fifteen minutes; the bell should be applied three times, or the bandage twice a day.

Whichever of the above methods is used, *it is as essential in the treatment of infection as in the case of acute inflammation that the area must be kept at rest.* This is brought about by supporting the affected part, if possible, in an elevated position, which much eases pain, and immobilising it by means of splints or slings of a suitable nature.

So soon as the *throbbing nature of the pain* indicates the *onset of suppuration* in the area, the time for treatment by congestion is past, and *immediate and free incisions* should be made into the tissues *to give exit to the pus.* It is not necessary or advisable to await the presence of definite fluctuation, for the alteration of tension in the tissues, apart from the relief resulting from the liberation of even a small bead of pus, is often enough very materially to ameliorate the local conditions, and allow the inflammatory process to resolve satisfactorily.

Incisions to be of value must be adequate in size, of an equal length throughout their whole depth, and made at the most dependent part of the abscess cavity or cellulitic area in order to provide free and efficient drainage for the pus. In this connection it must be remembered that the term "most dependent part" refers to the lowest portion of the inflamed area, with the part in that position of rest in which it will be maintained by the patient and the practitioner.

In cases of cellulitis involving a large area, several parallel incisions may be necessary, but where there is a cellulitis in the tissues around a definitely infective or fluctuating focus, incision and drainage of this focus should be first practised, and often will suffice to cure the whole condition. In making any incision the position of important anatomical structures must be borne in mind and their integrity respected; for this reason it is customary to *make incisions parallel to the course of vessels and nerves* and not across them.

Once the pus has been evacuated the area should be treated by any of the methods applicable in the treatment of the earlier stages of infection, and under such conditions closure of the wounds and resolution will not be long delayed, though the purulent discharge may continue for some days.

Persistence of a discharging wound in these cases, a condition known as a **sinus**, is usually due to (1) *inadequate drainage*, due either to the incision being inadequate, or not placed at the most dependent point of the area; it may, however, be due to (2) *the presence of necrotic or foreign material in the depth of the wound* which needs removal, (3) *want of rest of the part*, which must be remedied by judicious splinting, (4) the persistence of an epithelial or secretory lining, (5) the presence of a tuberculous or syphilitic infection.

Premature closure of an inadequate incision, with recrudescence of the inflammatory trouble, is best dealt with by a further adequate and suitably placed opening.

BACTERIOLOGY

Infection, as has been pointed out, is in every case due to micro-organisms, and it will be well, before proceeding further, to discuss the *bacteriology of infection* in so far as it concerns the surgeon. The importance of the study of bacteriology cannot be overestimated, for to bacterial infection are due the vast majority of those diseases which the medical man is called upon to treat; so we must remember that if a thorough knowledge of the cause and treatment of these conditions is to be acquired by the student, then an equal insight into the nature and conditions of growth of the causative organisms is imperative.

Bacteria are ubiquitous—they exist in their myriads in the air we breathe, the food we eat, the clothes we wear, and in our very skins and intestinal tracts; unless, therefore, very careful measures are taken to ensure their exclusion from the body tissues, they will enter through every small abrasion of the superficial layers, not only of the skin, but also of the mucous membranes of the respiratory and intestinal tracts.

Fortunately for mankind it is only a very small proportion of the many thousand species which are actively harmful, the vast majority offering no menace to health or life. Those few with which the physician and surgeon are concerned belong to the smaller group of micro-organisms, which, when introduced into the tissues, cause disease as a result of their infection, the so-called "*pathogenic organisms.*"

Bacteria, schizomycetes or fission fungi, form a very important group of the lower plants, consisting of minute unicellular organisms of various forms, but all devoid of chlorophyll. In structure they are simple, consisting of a delicate cell-wall of cellulose, containing a central mass of protoplasm, which may in some cases escape through the cell-wall as a series of fine hair-like processes (*flagellæ*) oscillation of which enables organisms so provided to move in a fluid medium. Non-flagellate organisms are incapable of active motion, but can be carried by currents of fluid or air.

Division and multiplication of bacteria is by simple fission and occurs at a very rapid rate, the divided organisms often adhering loosely to one another by means of a gelatinous capsule surrounding the cell walls. The cell protoplasm contains no obvious nucleus, though it may be vacuolated or contain granules.

As has been pointed out, reproduction normally takes place by a process of simple division, but under adverse conditions *spores* may be formed in certain rod-shaped bacteria (**Bacilli**). These are formed within the capsule of the organism (endospores), and are highly refractile under the microscope, due to their containing less water and having a thicker wall. Such spores are very resistant both to dry and wet heat, and will exist under conditions that ordinary bacteria cannot withstand, such as boiling for a short period (five minutes) or immersion in antiseptics, and *inasmuch as the causative organisms of some of the most deadly diseases are spore-forming this fact must be borne in mind.*

Of those organisms which are of interest to the surgeon, *B. tetani* (the organism of lockjaw) spores in the body, and *B. aerogenes capsulatus*, *B. œdematis maligni* (organisms of gas gangrene) and *B. anthracis* (anthrax, malignant pustule and woolsorters' disease) spore outside it. The first three organisms are strict anaerobes, *i.e.*, they grow only in the absence of oxygen, but it must be borne in mind that their spores can exist where oxygen is present.

The position of formation of the spore in the organism is of use in diagnosis; thus the spores of *B. tetani* occur at one end of the rod, giving the classical drumstick appearance, whereas the spores of the other organisms occur in the centre.

Although the classification of bacteria is, strictly speaking, based on their morphology, yet for practical purposes it is customary to classify them by their shapes and arrangement in culture when they divide, as these are characteristic. Thus *bacteria* fall from their shapes into *three great groups:* (1) *Cocci*, round; (2) *Bacilli*, straight rods; (3) *Spirilla*, curved rods; these groups being subdivided by their method of fission, or by their cultural characteristics, into a number of different organisms.

Cocci. Into this group fall the organisms which are spherical or nearly so, and according as they divide in one or more planes of space, this group is subdivided into—

(*a*) *Streptococci*, which divide in one plane only, and so become arranged *in chains* like beads on a string.

(*b*) *Diplococci*, which again divide in one plane, and which, after division, remain approximated in pairs.

(*c*) *Staphylococci*, which divide irregularly in two or more planes, and so appear *in clusters*. Inasmuch as this is the organism commonly met with in the pus in abscesses, it is called *Staphylococcus pyogenes*, and is further subdivided, according to the colour of its cultures, when grown on a gelatin or agar slope, into three groups: (*a*) *Staphylococcus aureus* (orange); (*b*) *Staphylococcus citreus* (yellow); (*c*) *Staphylococcus albus* (white).

(*d*) Rarely cocci may divide in two planes and remain in apposition, in which case the term *Tetracocci* is given to the group of four which results.

(*e*) Division in three planes, resulting in the formation of groups of eight cocci, somewhat resembling a bundle tied around and across, is characteristic of *Sarcinæ*, but further multiplication gives rise to composite masses closely resembling staphylococci in appearance.

Bacilli. Bacilli are straight rod-shaped organisms, which vary in size, shape, and the presence or absence of flagellæ. They may divide by longitudinal or transverse fissure, and hang together in chains, or separate on division. Usually they can be distinguished from each other only by cultural characteristics and staining reactions. As has already been pointed out, spore formation occurs in some varieties of this group.

Spirilla. Spirilla are rods bent in three planes, and therefore, if long enough, have a corkscrew appearance; they are not common as a cause of disease, and the only important one is the organism of Asiatic cholera, which, as it is short in size, is known as a *vibrio*.

It is not necessary or desirable in a text-book on surgery to enter into the cultural characteristics of the various pathogenic organisms, such a subject being of too vast a scope and too technical a character to be dealt with outside a book of bacteriology.

Further research, such as cultural characteristics, staining properties, or inoculation into living animals, in order to prove that the organism isolated is actually the cause of the disease, should be left when necessary to an expert bacteriologist.

There are certain other low vegetable organisms causing disease which require mention, most important among these from a surgical standpoint are—

(1) *Streptothrices*, which are low-type hyphomycetes (filamentous fungi) and differ from the bacteria in branching and forming matted masses of filaments (*mycelium*). They also form chain spores, the protoplasm collecting in the sheath in a number of beads separated by spaces. There are many varieties of *Streptothrix* which can produce the clinical lesions of *Actinomycosis*, *Madura foot*, *Ringworm* (Tinea) in all its varieties, and *Favus*.

(2) *Blastomycetes* or yeasts cause skin lesions, and if in the throat give rise to *thrush*, though its causative organism, *Oidium albicans*, is by some authorities regarded as a streptothrix.

(3) Certain microscopical *animal organisms*, unicellular in type, are of great importance in surgical diseases, since the *spirochætæ* of *syphilis* and various tropical diseases, the *trypanosomes* of sleeping sickness, and the *amœbæ* of *dysentery* and *organisms of malaria* all belong to this class.

Life Conditions of Bacteria. As has been pointed out, bacteria exist in great numbers everywhere, but a certain amount of moisture is necessary for their active proliferation, and even the spore-bearing forms are destroyed by exposure for over half an hour to direct sunlight.

In the air they remain in suspension attached to particles of dust or moisture, and thus, if the air is still, will settle with the dust. In water they exist in numbers directly proportionate to the impurity of the supply, and are not given off from the surface into the air. The water supply of towns should be purified of bacteria. In earth vast numbers of bacteria exist, those near the surface being "nitrifying" organisms and most important in agriculture. An important group met with, especially in cultivated soil, is that of the *anaerobic* organisms, of which *B. tetani* and the organisms of gas gangrene are the most important from a pathogenic standpoint.

Like any exposed surface, the skin is covered with bacteria, most of which wash off, but a few of which, notably the *Staphylococcus albus*, are normal inhabitants, and are found in the sweat and sebaceous glands as well as on the surface. They are thus very difficult to remove in the cleansing of the skin for surgical purposes.

These organisms are also normal inhabitants of the alimentary canal, including the mouth and anus, respiratory passages, and also the vulva, vagina and urethra (it should be observed that normally *no* organisms exist in the upper part of the nose, the posterior urethra in the male, vaginal vault in a virgin, the upper urinary and generative passages, and the gall-bladder, bile and pancreatic ducts, but any of these may become infected, and then they cease to be sterile).

These organisms, under ordinary circumstances and if confined to their natural regions, give rise to no signs of disease, but if they get into the blood stream in such numbers that they cannot be quickly destroyed, or if the patient is generally or locally suffering from loss of immunity (see p. 34), then these organisms may give rise to serious illness. It is noteworthy in this respect that the passage of organisms into the tissues is frequent without giving rise to any general or even clinical local signs of the inflammatory process set up in their destruction, but should such organisms enter an area, maybe in the deeper tissues, where stagnant fluid, blood clot, or already damaged tissue exists, then local infection of a more or less acute nature occurs; this is known as *auto-infection.*

Or, again, the disturbance of the fibrous tissue which has surrounded and encapsuled an old area of infection may frequently release organisms which have lain dormant in the area for some time, even for years, and light up the old infection by implanting such organisms in new areas. This is a change well known to surgeons as a result of opening up old septic or tuberculous wounds, reinfection with *B. tetani* being a danger to be particularly guarded against in these conditions.

Furthermore, individuals who have had a severe attack of a disease may tolerate the presence of active organisms of the disease in their tissues (*see* Immunity) without showing any signs of illness, and if these organisms are in situations whence they can be voided, such as the *gall-bladder or kidney with B. typhosus,* or *nose or throat with B. diphtheriæ,* they can cause disease in any other person who may become infected. Such cases are by no means infrequent sources of serious epidemics of either of the above diseases, and whenever such occur the presence of some such *carrier* should be sought.

Bacteria, like all plants devoid of chlorophyll, cannot synthetise protein from simple materials in the presence of sunlight, and have to be provided with formed organic nitrogen from animal or vegetable material. They fall into two great classes: the *parasites,* which can exist only on *living,* and the *saprophytes,* which can obtain nitrogen solely from *dead,* material; there exist, however, several organisms which can exist in both living and dead tissue, though they prefer either living (facultative saprophyte) or dead material (facultative parasite).

The term *pathogenic organism* is applied to those organisms producing disease, and must not be confused with the foregoing terms, as, although most pathogenic organisms are parasitic, yet saprophytes can produce disease even when not in the body, as in puerperal sapræmia; here the absorption of the toxins formed from the action of saprophytic organisms on the dead fœtal tissue in the body of the uterus gives rise to severe constitutional disturbance.

Water is as essential to the growth of bacteria as are combined nitrogen, and also certain salts and a suitable temperature, which in the case of most of the pathogenic bacteria is that of the body, 98·4° F. (37° C.). The necessity for water and salts must be borne in mind in surgery, and every precaution taken to prevent the accumulation of blood (by hæmostasis) or fluids (by drainage and accurate coaptation) in operation areas.

Light and heat are both deleterious to bacterial growth, facts made use of in sterilisation, where bacteria are destroyed by exposure to direct sunlight or ultra-violet rays, or more commonly by boiling or baking, or exposure to steam under pressure.

Certain micro-organisms, again, can exist only in the presence of oxygen, and are known as *aerobes*, whereas others can live only without it (*anaerobes*); though here, again, many organisms can exist either with or without oxygen, though they may do better in its presence (facultative anaerobes) or in its absence (facultative aerobes).

It should be noted that in the body both aerobes and anaerobes may exist together in the same area, owing to the former using up oxygen from the tissues, and thus allowing the latter to grow in the deoxidised area, *i.e.*, *B. tetani* will grow better in a wound exposed to air if aerobes are present—*i.e.*, organisms producing suppuration.

Toxins are the most important pathological substances produced by the bacterial metabolism, and though they have never been isolated in a pure form, they appear to be albumoses and to resemble enzymes in their action. They are intensely poisonous in the blood or tissues, although often harmless if taken by mouth, probably owing to the fact that they are very unstable and so easily destroyed in the stomach, as indeed they are by heat.

Toxins are either (1) *extra-cellular*, as in the case of tetanus and diphtheria, where the toxins are soluble and accumulate in the fluids in which the organisms grow, and are then absorbed and capable of action in parts of the body far removed from the area where the organism exists; (2) *intra-cellular*, as in the case of the tubercle bacillus, where the toxin is apparently confined in the organism and not found in the surrounding fluid.

Toxins may be *selective* in their action, *e.g.*, tetanus toxin attacks only the cells of the central nervous system, or *general*, as in the case of most pyogenic organisms, which attack impartially any or all tissues in which they may be implanted.

The clinical results of the action of toxins on the tissues are a more or less acute *inflammatory reaction*. Thus (1) if there is a great amount of toxin in an area, *death of the tissue in bulk* may result in *gangrene or necrosis* from its action, or (2) if the process is somewhat less acute and fatty infiltration has time to supervene before death of the cells, *caseation* will occur, or (3) if the inflammatory reaction called out is sufficient to limit the toxic action of the organisms so that *molecular or microscopic cellular death of tissue alone results*, then *suppuration occurs;* while (4) should the toxins produced be very feeble the inflammatory process will result in *resolution*, and the only sign visible will be *proliferation of fibrous tissue* and *scarring* in the affected area.

Other substances produced during the splitting of organic nitrates to supply the bacteria with nitrogen are—

1. *Acids*, such as lactic, butyric, etc.
2. *Alkalies*.
3. *Gases*, such as sulphuretted hydrogen, methane, etc.
4. *Pigments*, as in the well-known blue-green pus from *B. pyocyaneus*.
5. *Aromatic substances*, indol, phenol and skatol, to which the evil smell of certain bacterial cultures, notably of intestinal organisms, is due.
6. *Alcohols* and other similar bodies.

7. *Ferments*—diastase, invertase, etc.—made use of in commercial processes.

8. *Ptomaines*—certain crystallisable organic substances allied to the vegetable alkaloids, and at one time thought to be important factors in disease production and important in food poisoning (botulism).

9. The *toxins*, already mentioned, which are from a pathological standpoint by far the most important by-product of the analytic production of nitrogen from organic matter.

IMMUNITY

The power of resisting the invasion of bacteria and the action of their toxins is known as immunity, and it is a well-known fact that this power of resistance varies greatly with individuals, and indeed in the same individual, under different circumstances.

Thus there is in some persons a natural power to resist the infection of certain organisms, and in others the power to resist the action of the toxins of other organisms; this is spoken of as **natural immunity**, and may be possessed by an individual in a high degree. Under certain conditions, however, this power of resistance is much lowered or may be temporarily absent; such are (1) starvation or malnutrition from insufficient or unsuitable food; (2) exposure to cold and wet; (3) collapse, such as after severe hæmorrhage; (4) exhaustion; (5) exposure to a vitiated atmosphere: these last two causes explain the susceptibility of patients to infection after prolonged anæsthesia; (6) certain chronic poisons—this is well known in chronic alcoholics, whose power of resistance is much lowered; (7) age, though of no importance in natural immunity, yet plays an important *rôle* in acquired immunity; for the older the patient the greater the likelihood of immunity being acquired by a previous attack of the disease.

All these conditions lower the general efficiency of the individual and so render the body more liable to infection; but once invasion by micro-organisms has occurred, local lowering of the tissue vitality will predispose to infection occurring at that spot. Such local depression of resistance is usually the result of trauma, which if slight leads to a weak inflammatory reaction only in the area, and undoubtedly predisposes to infection, besides offering by the presence of unabsorbed blood clot an excellent medium for bacterial growth. Severe injury, on the other hand, producing as it does an intense inflammation, is less likely to be followed by infection, provided it is not so severe as to produce death of the tissue.

In this respect it should be borne in mind that *antiseptics are poisonous to tissue cells as well as to bacteria*, and that, as will be pointed out in Chapter IV. (Wounds), their use in strong solution, by damaging the cells of the tissues with which they come in contact, renders these ultimately more liable to the attacks of any bacteria which may infect the damaged area.

Again, the virulence of bacteria may be increased greatly by the presence of certain chemical substances, and this fact should be borne in mind when applying weak solutions of chemical antiseptics, for if these are not in sufficiently strong solution to destroy or inhibit the growth of the organisms they may actually increase the virulence of the bacterial toxins.

Acquired immunity is the result of the individual's body tissues having been acclimatised to the bacterium or its toxin, and is of two kinds:

(1) **Active immunity**, which is the result of a previous attack of the disease, either "natural," or from deliberate inoculation, whereby the patient is freed

from the risk of contracting the disease again. In this latter case it is obvious that unless the inoculated form of the disease is less severe and submits the patient to less risk than would the "natural" variety, should it occur, no advantage will accrue to the individual; so that it is only in those cases where, by any means, the virulence of the infection can be lessened, that **inoculation** of the organism or its virus is practised with a view to inducing acquired immunity, and so greatly lessening the risks that would be run by, and the sufferings of, the patient, should the disease be acquired "naturally."

The following is a list of the chief diseases in which *preventive inoculation* is practised, with a few remarks on the type of inoculation employed:—

(*a*) *Smallpox.* The so-called *vaccination* consists in the introduction of the attenuated virus of smallpox, so attenuated by its passage through the calf. The older method of direct inoculation from a human source, which was introducing the disease in its "natural" form, is not now practised since the introduction of the "calf lymph" in its satisfactory attenuated form.

(*b*) Injection of an emulsion of dead organisms (*vaccino-therapy*) is practised as a preventative to typhoid and paratyphoid fevers (T.A.B.), plague (Haffkine's serum), tuberculosis (Koch's T.R.), tetanus, cholera, and gonorrhœa.

(*c*) Emulsion of attenuated living organisms is injected into cattle to prevent anthrax, but is not used in man.

It must be borne in mind that immunity so acquired does not last for ever, and it will be necessary at intervals of time, which must be determined empirically, to reinoculate in order to secure efficient active immunity; this is a fact which is not fully grasped even by medical practitioners, a misunderstanding which has led more than anything else to the success of anti-vaccinationist propaganda in smallpox.

It may not be out of place to indicate the approximate periods for which efficient immunisation persists after inoculation, and after which only partial immunity can be expected unless reinoculation is practised.

Smallpox	5 to 7 years.
Typhoid and paratyphoid . . .	1½ to 2 years.
Cholera and plague	6 months to 1 year.

As is to be expected, where the patient has to overcome the toxins by the resistance of his tissues, more or less constitutional disturbance will follow inoculation, for which reason this form of *acquired immunity* is termed *active.*

(2) **Passive immunity** is acquired by the injection of the serum of an animal or individual who has already acquired an active immunity to an infection. This serum is known as *antitoxin,* because it is rich in certain substances of a protein nature, known as *antibodies,* which have the power of destroying the toxins produced by the specific organism concerned. This power is acquired by the individual inoculated without any constitutional disturbance; hence this form of *acquired immunity* is known as *passive.*

Examples of this form of immunity are numerous; some of the commoner diseases in which use is made of antitoxic sera are diphtheria, tetanus, hydrophobia, and various forms of streptococcal infection. In many of these diseases injections are given as a *prophylactic,* that is, with the object of having the antibodies already present in the blood to destroy the bacteria and their toxins, either as soon as they invade the tissues or before they can become sufficiently powerful to exercise any generally harmful influence.

In this respect the use of antitoxins is most successful; but it should be remembered that passive immunity is developed immediately following their injection (active immunity, on the other hand, taking a week or ten days to develop), so that this form of treatment should be tried, with hope of success, at whatever stage the disease is met with.

Moreover, inasmuch as passive immunity only lasts a short time, the active immunity developing in the individual as a result of the infection has to be relied on to combat further attacks of the disease. In this respect it must be remembered that not in all diseases does one attack confer immunity. Indeed, in some, such as influenza and erysipelas, one attack renders the patient more liable to a subsequent infection.

It is out of place in a text-book of surgery to enter into any detailed discussion on the theories of immunity, but it may be well to recall briefly that the antitoxins are produced from normal tissue cells, the plasma and connective tissue cells (macrophages of Metchnikoff), and the polymorphonuclear leucocytes (microphages); these cells, beside possessing the power of producing these *antibodies* (aggressins, agglutinins, opsonins, and alexins), which appear to ferment the bacteria and render them a suitable prey, also ingest and destroy the organisms, a process known as *phagocytosis*.

For the practical use of the power of acquired immunity, as practised in medicine by *vaccinotherapy* and the use of *antitoxic sera*, as well as for a detailed account of their dosage and the theories of their action, the reader is referred to works on bacteriology and medicine.

Anaphylaxis and serum sickness, which can be mentioned briefly in this connection, are seen but rarely, but may result from a dose of serum administered when the patient is already " sensitised," and are liable to occur if a second dose of serum is given within two or three years of a previous injection; as of antidiphtheritic serum in a second attack, or of antitetanic as a prophylactic for a second injury some months or years after a previous injection; they may, however, occur on a first injection. It usually takes at least ten days after a dose of serum for these conditions to develop.

Clinically. Sudden death may occur after syncope, or the patient may show all the signs of intense toxæmia, with dyspnœa, rapid pulse, fainting, purpuric skin eruptions and great prostration; persistent and distressing vomiting is common.

It is wise, therefore, not to run the risk of such a condition occurring, however unlikely, and this may be prevented by a preliminary injection of a few minims of serum subcuticularly, when, if anaphylaxis is likely, intense urticaria and a feeling of *malaise* will result in from a few minutes to a few hours. Needless to say, if any such reaction results, no further injection should be given.

If the condition has actually developed, treatment consists in rest in the prone position and the administration of stimulants to conserve the heart. Transfusion may prove of great benefit in these cases; inhalation of ether and injection of atropine sulphate, gr. $\frac{1}{100}$, are also valuable.

Desensitisation of a patient who has previously been given serum, and shows an urticarial reaction to a small subcuticular dose, can be carried out easily. An injection of 10 ♏ is given subcutaneously, followed in an hour's time by a further 1 c.c. of serum if no ill effects have occurred. Should nothing untoward follow, which is unlikely, the full dose of serum may be given in from four to six hours.

CHAPTER IV

INJURIES — CONTUSIONS — WOUNDS — HÆMORRHAGE— SHOCK AND COLLAPSE — BURNS AND SCALDS— FROST-BITE

UNDER the heading of injuries fall all the groups of tissue irritation other than those due to bacterial infection and tumours, which will be considered separately (see Chapters V. and VI.), and, as has been shown in the consideration of the processes of inflammation, this change is produced by all forms of injury in the body, and is, indeed, the normal process by which the tissues replace the damage sustained to themselves as a result of trauma.

A wound has been defined as the forcible solution of continuity of any of the tissues of the body, but it is more usual to limit the word " wound " to injuries of the soft parts with involvement of the skin or mucous membranes. The best definition of a wound is, therefore, that it is the forcible solution of continuity of the skin or mucous membrane together with the underlying soft tissues of the body, injuries of the bones being classed separately as fractures.

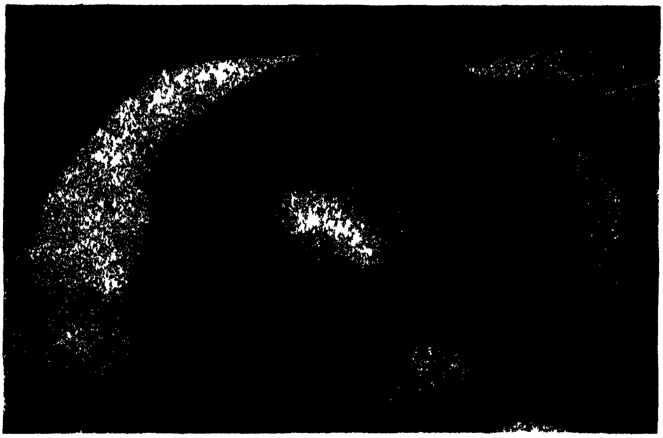


FIG. 7. Bruising on the buttocks.

A contusion is an injury of the soft parts in which the skin does not rupture, and is usually due to a blow with a blunt instrument, such as a hammer or a fist, or to a severe wrench. In the neighbourhood of a joint the resulting contusion is known as a sprain if it is accompanied by damage to the ligaments.

As a result of the tearing of the tissues, blood is extravasated among them in a varying amount, which by the changes in the pigments during absorption gives rise to that well-known phenomenon **"the bruise,"** with its puffy subcutaneous swelling, pain and discoloration, so well seen in a " black eye," the changes in the colour of which are due to the gradual deoxidising decomposition and absorption of the blood pigment. Should a larger vessel be torn, the extravasated blood may collect as a localised effusion, till its spread is limited by the pressure of the surrounding tissues. Such a localised collection is known as a **hæmatoma,** and can be detected as a rounded fluctuating mass in the bruised area, the edges of which are usually hard or boggy, due to the coagulation of the blood where it is in contact with the damaged tissues. Such a collection of blood may remain fluid for some days and absorb very slowly, so that, inasmuch as the contents make an excellent culture medium for bacteria and are thus prone to infection, it may be advisable, if it is very large, to incise the hæmatoma, turn out the clot or fluid blood, and sew up the wound. Great care must be taken to observe all aseptic precautions (Chapter I.).

An infected or suppurating hæmatoma will have all the signs of an abscess, and should be treated as such with adequate incisions (see Abscess, p. 69).

Clinically, a contusion usually can be diagnosed easily from the history of injury and the swollen, discoloured and painful condition of the part, but in this connection it must be remembered that the laxer the tissue the greater the swelling and the less the pain, and *vice versâ.* Thus in a black eye the lax tissues in the eyelids allow of extensive swelling, whereas the tighter tissues in the forehead and cheek, though much less swollen, cause far more pain. Another point to bear in mind is that if the extravasation of blood occurs deep to a dense layer, such as the fascia lata of the thigh, it may be some considerable period, days or even weeks, before the bruising shows on the skin, and the bruise may then appear at some distance from the site of injury, the blood having tracked away from the site of the injury.

The treatment of contusions, if seen early, consists in rest and the application of cold compresses under an even-pressure bandage, with the object of limiting the effusion in so far as possible. In the later stages no special treatment is indicated, but the absorption of the effusion may be assisted by gentle movements and massage. In cases of extensive bruising a hot bath is useful in relieving pain.

Sprains are to be treated on these general principles, but an X-ray photograph always must be taken to ascertain that no injury has occurred to the articular surfaces and bones (see Chapter XV.).

WOUNDS

These, which are sometimes spoken of as open wounds, are classified according to their appearance into three groups :—

1. Lacerated.
2. Incised.
3. Punctured.

They will be discussed under these headings, although frequently the wounds met with in practice are found to embody the characteristics of two or three classes together.

(1) **Lacerated Wounds.** It is well to discuss, firstly, lacerated wounds, as they are most nearly allied to contusions and often associated with them, being produced for the most part by extreme violence with a blunt instrument, such as a hammer, which, besides crushing and breaking the skin, will cause extensive bruising of the underlying tissues. The simplest of lacerated wound is the *graze* or *abrasion,* so commonly seen in

everyday life, while the most severe forms usually result in civil practice from machinery accidents, and in war from shell and bomb wounds.

These wounds are usually irregular in shape, and the skin around is torn and discoloured ; the wound varies in depth, and often areas of tissue or skin are lying partially avulsed and crushed in and around the wound, while whole areas may have been torn away. The surrounding tissues are swollen and discoloured and frequently ingrained with portions of clothing or other foreign matter, such as oil or dirt, which has been ground in by the violence of the accident. It is a noteworthy fact that the crushed tissues are very insensitive to pain, owing to destruction of the nerves and consequent inhibition, and so, unless there is extensive loss of blood, the general constitutional upset (Shock, p. 51) is slight ; further, as, owing to the nature of the violence, the vessels are torn roughly across, the coats will retract and the amount of *hæmorrhage is usually small,* and, moreover, the extensive exposure of damaged tissues favours free and early clotting of the escaped blood (see Hæmorrhage, p. 48).

FIG. 8. Gangrene of the superficial tissues following an extensive lacerated wound of the leg.

It must be borne in mind that the tissues may be so severely crushed that they will be destroyed, or that the tearing of the vessels by cutting off the blood supply to certain areas may lead to subsequent death of large masses of tissue (Necrosis or Gangrene, p. 152). In cases where large portions of the body, such as a limb, are avulsed it will be found that the denser and more fibrous structures, such as tendons, will be projecting from the torn surface as long, stringy and disorganised masses.

The bites of animals come under this class of wound and are very liable to infection. Healing in such wounds is always by second intention (granulation) (Chapter II., p. 23).

(2) **Incised wounds** are produced by any sharp cutting instrument, such as a razor or the surgeon's knife , occasionally they may be produced in regions where the skin is tightly stretched over the bone by a blow from a blunt instrument, *e.g.*, a police truncheon on the scalp often will give a clean-cut incised wound, but in these cases there is always bruising of the surrounding tissues.

The edges of an incised wound may be in apposition, but usually gape to a greater or lesser degree, depending on the size of the wound and the elasticity of the cut tissues. As a general rule such wounds are longer than they are deep. *Hæmorrhage is free* from the cleanly-divided vessels, and there may be considerable shock from the stimulation of the cut nerve surfaces. There is no bruising or tearing of surrounding tissues, so that healing will take place rapidly, and is normally by first intention (Chapter II., p. 23).

All incised wounds should be examined carefully in their deeper parts to see that no important nerves or tendons have been severed, as neglect to observe this precaution may lead to serious deformities. If such damage is found, the divided structures should be united at once; nerves with fine catgut and tendons with silk or thread (*cf.* Nerve and Tendon Suture).

The chief danger in incised wounds is from hæmorrhage resulting from severance of blood vessels, which if large may bleed so freely as to endanger the patient's life in a very short time. In such cases immediate treatment is called for (*cf.* Hæmorrhage, p. 47).

(3) **Punctured wounds** are caused by the penetration of some sharp instrument and are small and deep. They are popularly called stabs, and commonly result in civil practice from pins, needles or nails, and in war from bayonet wounds. They are serious, as, although the external opening is usually small and insignificant, (*a*) extensive damage may result to deeper structures; (*b*) severe hæmorrhage may occur into body cavities penetrated by the instrument, with no signs of external bleeding; (*c*) a portion of the instrument may be broken off and remain in the depths of the wound; this is most commonly seen in the case of needles; (*d*) should infection occur, the pus is pent up under pressure in the depth of the wound, and will infiltrate the surrounding tissues before escaping along the track of the wound, as occurs in both the other varieties of wounds, where escape from the wound is the path of least resistance. Small punctured wounds of the fingers frequently become infected and give rise to whitlows (Chapter IX., p. 228).

Snake bites. Another form of penetrating wound worth mention is the *bite or sting* of various creatures, such as snakes and wasps. These are accompanied by the injection of poisons, and are therefore serious, often causing death in a short period. Such wounds are common in the summer months, and in this country the only ones to cause anxiety are the bite of the viper and extensive wasp or bee stings, though even these are not likely to give much cause for anxiety unless inflicted on the bare flesh, as the clothing usually retains the poison from the fangs or sting in transit. The more venomous snakes of tropical countries give rise to the most virulent and acute forms of poisoning, often with very rapid death, the substance injected from the fangs probably being an albumose which is harmless in the stomach.

Clinically there is a double punctured wound, followed by great pain and swelling spreading up the limb. If the patient survives, local gangrene may follow. Within a few minutes or hours, depending on the nature of the snake, marked collapse with faintness, blindness and terror sets in. Vomiting, hæmatemesis, cold clammy skin and dilated pupils occur, with a rapid, flickering pulse. Death may occur in anything from half an hour to two days: if alive after two days the patient will probably survive.

Treatment. A tight string may be tied round the limb above the wound, and bleeding must be encouraged, if possible by suction. The bite is best excised and the wound is filled with peroxide of hydrogen, potassium permanganate or ammonia. General treatment is necessary in the form of stimulants such as alcohol, especially whisky or brandy, digitalis, strychnine, etc. In some instances an antiserum in the form of an antivenene is available.

Treatment of Wounds. There are certain general principles laid down for the treatment of all wounds irrespective of their nature, and these fall into two great classes :—

A. Immediate.
B. Subsequent.

(A) The *immediate treatment* of a wound is usually a matter for first aid and of an emergency nature. It consists essentially in (*a*) the arrest of hæmorrhage; (*b*) the application of a temporary dressing to protect the wound.

Hæmorrhage may be arrested as a first-aid measure by direct pressure on the wound, or if this does not suffice, by the application of pressure on the artery supplying the wounded area; this pressure should be just sufficient to obliterate the pulse of the artery, so as to avoid undue damage to the walls of the vessel, and is best maintained by the use of some form of tourniquet (*see* Arrest of Hæmorrhage), which must never be left on for more than half an hour, as otherwise gangrene of the part will result from the cutting off of the blood supply to the tissues. *No attempt should be made to explore the wound for fear of the danger of introducing infection;* for the same reason the application of cobwebs as a hæmostatic cannot be condemned too strongly.

The dressing applied should be of clean, if possible sterile, linen, and should be placed directly on the wound and bound on firmly. In order to sterilise the dressing, if practicable, it may be wrung out of boiling water or dipped in some antiseptic, such as Condy's fluid or sanitas; if, however, no such means of sterilisation are available, the inner surfaces of a folded handkerchief can be directly applied without handling.

(B) *Subsequent treatment* will be carried out under proper aseptic or antiseptic precautions by the medical man at a hospital or in the surgery. It is a golden rule to regard all wounds, other than those made by the surgeon in the operating theatre, as infected, and to treat them accordingly. Experience amply justifies these measures against suspected infection being carried out in all cases, for, firstly, the instrument inflicting the wound is seldom surgically clean, and secondly, clothing and foreign bodies may be present in the wound; hence lacerated and punctured wounds are from their nature more liable to infection than incised wounds.

The first step is, then, the cleaning of the wound, and as this process often restarts hæmorrhage, *permanent arrest of hæmorrhage* by obliteration of the bleeding vessels at their point of section must be carried out simultaneously. For this purpose it is necessary to administer a general anæsthetic if the wound is at all extensive.

1. *Cleaning of the wound* may be accomplished in any of the following ways: (*a*) *By the total excision of the whole wound.* This is the most rational and only satisfactory treatment, as it removes the infected area, and, if practicable, is to be carried out in every case, but is not to be attempted in wounds of over ten hours' duration as infection will by then have spread to the surrounding tissues. The size or situation of the wound may render this impossible, in which case partial excision of the wound may be resorted to, but is not so satisfactory; it should be directed to the removal of the more superficial, and therefore more likely to be infected, parts of the wound, and the removal of all crushed and torn tissue and foreign material.

(*b*) The cleansing of the wound by irrigation with warm sterile or antiseptic fluids. This must be very thoroughly carried out, and may be assisted by gentle scrubbing of the tissues with a sterile (boiled) nail brush. Inasmuch as the good results appear to be mainly from the mechanical action of the wash, equally good results would be expected from irrigation with sterile water as with antiseptic lotions, and this is found to be the case. It is not, however, always possible to secure the necessary volume of sterile water or saline, in which case weak antiseptic solutions should be used. Strong antiseptics will damage the tissue cells, and so render them liable to infection and hinder repair.

Many antiseptics are in popular use, the best of which are hydrogen peroxide (5 volumes), which gives off nascent oxygen in contact with the damaged tissues, and in addition tends by active oxidation to destroy any anaerobic organisms which are deep in the wound (*e.g.*, *B. Tetani*, the organism of lockjaw); carbolic acid (1–20 to 100); perchloride of mercury (1–2,000); flavine or acriflavine (1–1,000); iodine (2 per cent. in spirit), or eusol. The solution should in all cases be used warm, and very copious irrigation carried out.

(*c*) In cases of severe lacerated wounds where much foreign matter is ingrained, actual curettage with a Volkmann's spoon may be necessary for its removal.

2. *Hæmorrhage is permanently arrested* by the ligature of all bleeding points, after the cut ends of the vessels have been seized with Spencer-Wells artery forceps (*cf.* Arrest of Hæmorrhage).

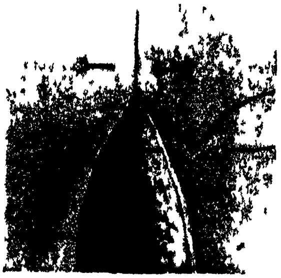
3. The next step following the cleansing and hæmostasis is a *thorough exploration of the wound* to ascertain the extent of the damage to the various structures, especially nerves and tendons, with a view to their immediate repair. This must be carried out very carefully in deep wounds, and will be all the more thorough in regions the anatomy of which makes the damage of important structures likely.

In cases of *perforating wounds involving the pleural and peritoneal cavities* it is essential to open and explore thoroughly, if there is cause to suspect damage to large vessels or the intestinal tract (*cf.* Injuries of the Pleura and Peritoneum).

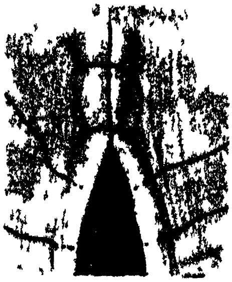
In perforating wounds in the neighbourhood of the joints, it may be justifiable to immobilise the part with extension and keep the patient under observation. This is so in cases where there is no escape of synovial fluid or where the escape is so free that the wound is cleaned from within by the escaping fluid. In all other cases the wound must be explored, if possible excised, and the synovial membrane sutured (see Wounds of Joints, p. 593).

A probe should never be used in these cases, because of the danger of conveying infection from the superficial to the deeper parts of the wound, which from their position are less liable to be contaminated, the instrument which produces the wound probably cleaning itself in traversing the superficial tissues.

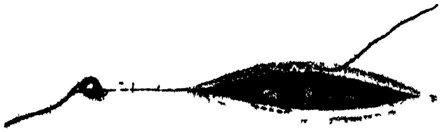
4. *Coaptation* of the cut edges is now carried out by means of sutures, though often only partial apposition is possible in lacerated wounds. *Suture material* may be of silk, cotton, silver wire, catgut, salmon-gut or horsehair; occasionally metal clips such as Michel's are used to approximate the skin edges. The usual material used is salmon-gut or silk, but whatever material is used must, of course, be sterile, and care must be taken in the approximation of the skin edges that these are truly in apposition and not overlapped or rolled in. Should difficulty be experienced in approximating the deeper tissues, deep tension stitches should be employed, preferably of an absorbent material, *i.e.*, catgut, and in the same way if great stretching is necessary to appose the skin edges, tension stitches, taking large bites of



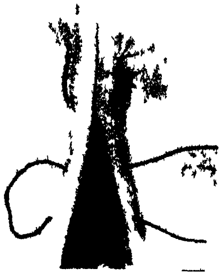
Stitch to secure approximation of deep tissues and skin edges.



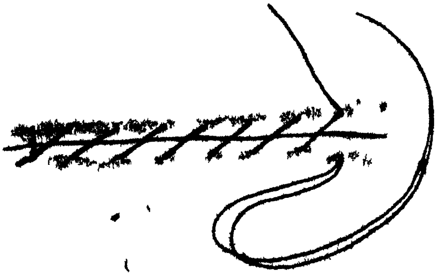
Simple stitch.



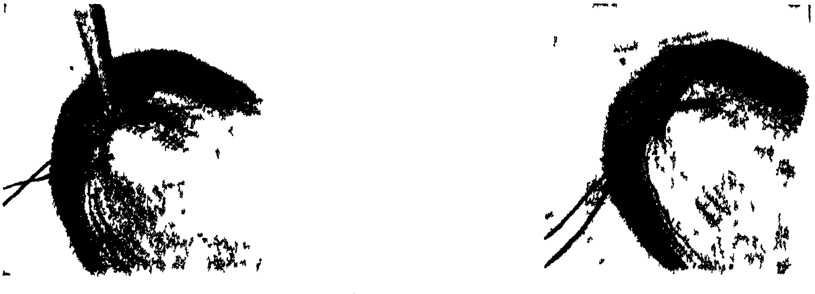
Halstead's subcuticular stitch.



Mattress stitch.



Glover's stitch.



Purse-string suture, showing invagination of appendix stump.

Fig. 9.

deeper tissue and skin, should be used to reinforce the stitches of coaptation.

Suturing may be either by a series of separate stitches (interrupted suture), or by a continuous suture extending from one end of the wound to the other; this may be either cuticular or subcuticular. Generally interrupted sutures should be employed, as they allow for the escape of pus in the event of infection. The various types of stitch are illustrated in Fig. 9.

5. If necessary *drainage* of the wound must be carried out by means of tubes or strips of corrugated rubber. This is necessary where hæmostasis is imperfect, or where loss of tissue leaves a space in the deeper parts of the wound; also if infection is thought likely.

As a general rule *stitches should be removed* on the eighth day, but if there is great tension they may be left till the tenth day, after which they begin to ulcerate through the skin and no longer maintain the apposition if healing has not occurred. In face wounds, stitches should come out on the third or fourth day. Michel's clips should be removed on the third or fourth day, except in face wounds, where they are removed in forty-eight hours.

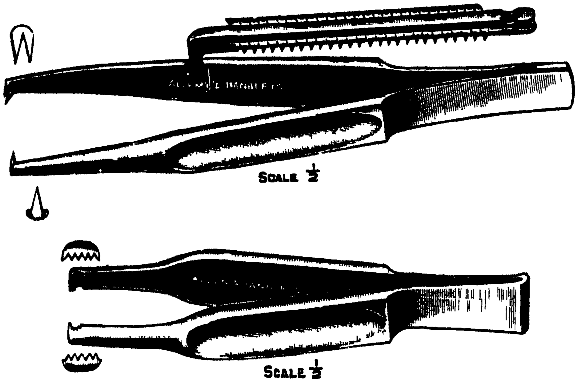


Fig. 10. Michel's Clips.

In the event of the onset of suppuration, alternate stitches may be removed early to permit of the escape of the pus from the wound.

6. *A sterile or antiseptic dressing* of gauze should be placed next on the wound and bandaged firmly in position. This serves to protect the wound from infection and local irritation, and the firm bandage, besides aiding hæmostasis, acts as a valuable adjunct to resting the injured part.

7. *Rest* of the injured part is procured by bandages, slings, occasionally splints, and, if necessary, rest in bed in the recumbent position.

8. Lastly, it may be necessary, either because of the extent of the wound or because the injury to the tissues is accompanied by such severe injury to bones and joints or extensive stripping of the soft parts or skin as subsequently to ensure inutility of the part, to *amputate* the wounded part. Amputation should be regarded as the last resort of the defeated surgeon, but, if performed, should be carried out through undamaged tissues and in such a manner as to ensure as useful a member as possible under the circumstances. It is more frequently necessary in the case of lacerated wounds with extensive damage to deeper tissues and bone.

9. In all cases where soil or road dirt is in the wound a prophylactic injection of 500 units of *anti-tetanic serum* should be injected intramuscularly to obviate

the danger of tetanus (*q.v.*), and in similar cases with extensive muscle laceration, *B. welchii* antiserum (40 c.c.) should be given to prevent the risk of gas gangrene.

Healing of the wound commences immediately and is the more rapid the closer the tissues are approximated, as there is less blood clot to be disintegrated and absorbed. As indicated in Chapter II., this is really a process of inflammation, the blood clot being invaded and destroyed by leucocytes and the resulting tissues invaded by capillary loops, which revascularise the area, and then in their turn become obliterated by the pressure of the newly-formed fibrous tissue (*cf.* Resolution, Chapter II.). It will be seen that the process of healing is identical with resolution. If the tissues are approximated and no infection occurs, healing takes place by *first intention*, and should have sufficiently progressed in ten days to allow of the tissues remaining in apposition without support under normal conditions, Should the tissues not be approximated or infection occur, then healing will be by *granulation* and take much longer, the larger the wound the longer being the time taken, as the granulations arising from the surfaces have to grow up and fill the gap. Should the area be very great, the fibrous tissue at the periphery may by strangulation of the vessels in the granulations cause the centre of the wound to remain unhealed or the scar to break down. Such a condition should be treated by ionisation, ultra-violet rays or massage, in order to increase the blood supply to the area.

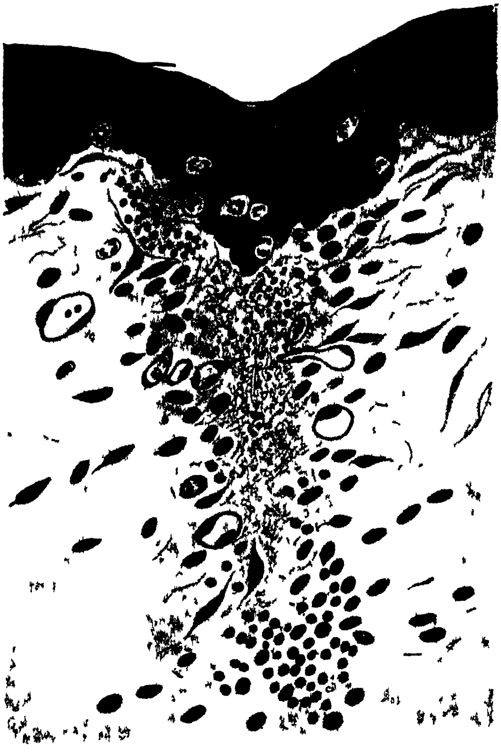


FIG. 11. Healing of an incised wound by first intention. (After Warren)

It is frequently possible to hasten the healing of granulating wounds by suturing the granulating surfaces together (*healing by union of granulations*), but this should never be attempted if infection is present, though a culture from the surface in which only *Staphylococcus albus* is found does not contra-indicate the procedure.

Causes of Delayed Union or Non-healing of Wounds. Union, however, may be delayed by a variety of causes other than inadequate approximation of tissues, the chief of which are sepsis, syphilis, the presence of foreign bodies, and undue movement of the wound edges on one another. Such general diseases as tabes, renal disease, tuberculosis, diabetes, etc., will delay healing.

Sepsis, when it occurs, must be dealt with by adequate drainage (débridement) (*see* Infection), which may be aided by irrigation with weak antiseptics led into the deeper parts of the wound by small perforated tubes (Carrel-Dakin method).

Syphilis which exists already as a general constitutional infection must be appropriately treated (*q.v.*).

Undue movement can be combated by suitable fixation of the area in splints or by adhesive plaster.

Foreign bodies should have been removed in cleansing the wound, but may have escaped detection, or in the case of punctured wounds may not have been located. If the foreign body is of metal, such as a needle, it should be located and localised by X-ray (*q.v.*), and removed as soon as possible, as such bodies travel freely in the tissues. Bodies not opaque to X-rays, such as cloth or wood, are less easy to detect, but may be probed for, or removed by exploration and curettage.

Gunshot wounds are seldom met with in this country in civil practice, but are, of course, common in war surgery. Generally speaking, they fall into two types :—

1. Perforating wounds due to rifle and revolver bullets.
2. Lacerated wounds from bombs, high explosive shell or shrapnel.

The general principles laid down for wound treatment apply to both these types, but under the conditions of war early treatment is not always possible, and infection is much more probable : hence treatment usually should be more drastic than in civil practice ; moreover, the presence of the bullet or metal must in all cases be remembered ; this should be demonstrated and the position localised by X-ray photographs.

Under ordinary circumstances the bullet should be removed, if possible, when the wound is cleansed, but extensive search for deeply-placed or minute fragments is contra-indicated, as much destruction of tissue is thereby entailed, and in many cases such particles may remain embedded for years without giving rise to any trouble. Similarly, in the absence of X-rays, no attempt should be made to seek for a missile not localised by touch or seen lying in the depth of the wound. Never attempt to search for a bullet in the brain unless it is accurately localised, and even then it is doubtful wisdom to operate unless its presence is giving rise to symptoms either from pressure or infection, as the damage to brain tissue consequent on the exploration is considerable. Experience in the last war has shown that extensive lacerated wounds of the limbs, with compound fractures, especially if involving or near the joints, are best treated by immediate amputation, as conservative measures are attended with a long and painful healing and convalescence, consequent on the extent of the injury and the infection which almost always occurs, and, moreover, even if the limb does not have to be ablated subsequently as a result of the latter complication, it is usually painful and practically useless.

In cases where the abdomen and chest are penetrated, an exploratory laparotomy or thoracotomy should be immediately undertaken in all cases to ascertain if and to what extent subjacent viscera are damaged (see Vol. II.). Such an operation, of course, should be performed only in a proper operating theatre and by a competent surgeon. In connection with gunshot wounds, it must be borne in mind that infection with anaerobic gas-forming organisms and subsequent gas gangrene (*q.v.*), and also tetanus, are complications to be feared greatly and guarded against by adequate cleansing with hydrogen peroxide and the administration of appropriate antitoxic sera (Chapter II., p, 35). Fuller details as to treatment of gunshot wounds will be found in Chapter XXV.

HÆMORRHAGE

It is perhaps not inappropriate at this juncture to deal with the subject of hæmorrhage, a complication seen in all wounds.

(1) **Primary hæmorrhage** results from the wounding or severance of any blood vessel, and will vary in its character with the nature of the vessel cut.

Arterial hæmorrhage will be bright red in colour and occur in forceful jets, synchronising with the heart-beat, and being more powerful the larger the artery wounded. If emerging from a deep punctured wound the blood may come in a steady stream and be dark in colour.

Venous hæmorrhage is dark blue or purple in colour, and comes in a continuous stream from the wounded vessel, though in the case of the wounding of veins closely adjacent to arteries it may have a transmitted pulse. If a large vein is wounded the blood may be projected several inches from the wounded surface.

Capillary hæmorrhage is a steady ooze of dark blood from cut tissues where no large vessels are involved. The blood on escaping into the air rapidly absorbs oxygen and becomes bright red in colour.

Extravasation of blood is a term applied to the escape of blood from the damaged vessels into the connective tissue under undamaged skin ; the result is a *bruise* or a *hæmatoma* (see p. 38). Blood may escape from damaged vessels into one of the body cavities, such as the pleura or peritoneum, without giving rise to any visible or external bleeding ; such a condition is known as *concealed or internal hæmorrhage,* and may be very difficult of diagnosis, and, not infrequently, fatal. It can be detected best by the constitutional signs of bleeding, with a history of injury locally and signs of local effusion of fluid into the body cavity concerned (*see* Injury to the Pleura and Peritoneum).

When, however, it escapes from a wound *external hæmorrhage* is said to occur, and various names are given to the occurrence of such hæmorrhage from the orifices as a result of injury to or diseases of deep organs.

Hæmoptysis is the title given to the escape of blood from the lungs *via* the air passages and mouth ; such blood is bright red in colour and usually frothy from admixture with air, while it appears to be coughed up.

Hæmatemesis is blood escaping *via* the mouth from the stomach or upper duodenum ; such blood is dark, frequently clotted or semi-digested and brown in colour, containing solid particles of clot which have earned it the name of "coffee-ground vomit." It is well to remember that such blood may have run down into the stomach of a patient rendered unconscious by a fractured skull, being in this case derived from that situation and vomited subsequently.

Melæna is used to denote blood escaping from the anus ; such blood may be dark and tarry and intimately mixed with the fæces if derived from high up in the bowel, or bright red and clotted if derived from the rectum, where the common cause of such a condition is piles.

By *hæmaturia* is meant the presence of blood in the urine, and by *epistaxis* the escape of blood from the nose.

Clinical Features. The signs of hæmorrhage are local and general.

(*a*) *Local signs* are obvious if there is *external hæmorrhage*, but in cases of *internal hæmorrhage* it is on the general constitutional signs that the surgeon mainly relies in establishing a diagnosis, although in such cases marked local tenderness and the presence of a dull note on percussion, which dull area varies with the patient's position (*shifting dulness*) if the blood is in a cavity such as the pleura or peritoneum, may be very useful in localising the site of the lesion.

(*b*) *The general signs* are mainly the result of cerebral anæmia from the loss of blood, and the consequent passage of a lesser volume in the vessels. Thus in severe hæmorrhage, as from division of the aorta or common femoral, the patient rapidly loses consciousness, becomes cold and clammy, with a blanched skin, and dies almost immediately after taking two or three rapid gasping breaths. In a less severe case the onset of these signs is less sudden, the pulse becomes rapid and irregular, and is very easily compressible, the vessels emptying and collapsing during cardiac diastole. The respiration becomes rapid, shallow and gasping, and is accompanied by great restlessness, the patient throwing himself about and clamouring for air, or asking that windows be opened. The skin is cold and covered with a slight clammy sweat; it is also blanched; the cheeks appear shrunken, due to absorption of fluid from the tissues into the blood stream. Great thirst is present. There is a sense of impending death, a sinking sensation is experienced in the epigastrium, noises are heard in the ears (tinnitus), or flashes of light seen before the eyes, and, if the bleeding be unchecked, loss of consciousness shortly precedes death.

Children and old people bear loss of blood badly; therefore in them the signs of hæmorrhage are marked, but whereas old people recuperate but slowly from the effects, children recover very rapidly.

Treatment. Before considering the treatment appropriate to hæmorrhage, it is well to discuss the *natural means of arrest* of bleeding from severed vessels; this is brought about firstly by the *clotting of the blood*, and secondly by the *contraction of the muscular and elastic coats* of the damaged vessels, and thirdly by the *fall in blood pressure* consequent on the loss of blood and subsequent collapse.

Thus, hæmorrhage is less severe when the vessels are torn across; in lacerated wounds there is a length of pulled-out tunica intima to retract and contract, and so more adequately block the vessel lumen than when it is cut cleanly by a sharp instrument (incised wounds). Again, if the vessel wall is only cut for part of its circumference, bleeding will be very free, as the walls cannot collapse. This is a phenomenon well known to surgeons, who frequently may be hindered while operating by hæmorrhage from a partially-severed small vessel, which ceases as soon as the vessel is completely cut through.

The natural process of the clotting of the blood on its escape from the vessels depends on the formation of certain ferments in the plasma by its contact with damaged tissue cells which convert the souble albumen in the plasma into the insoluble fibrin, so well known to all in its jelly-like consistence in blood clot. The amount of calcium salts in the blood also has an important action, especially on the time taken in clotting, bloods deficient in calcium clotting far more slowly than those with a normal calcium content. Moreover, the greater the extent of damaged tissue, the more ferment there is for the clotting of the blood, and apart from this a larger surface of solid particles for the blood to clot on; thus hæmorrhage is more quickly naturally arrested in lacerated wounds.

Subsequently the clot organises (*see* Healing of Wounds and Inflammation) in and around the damaged vessel (internal and external coagula), which thus becomes obliterated and replaced by a cord of fibrous tissue, though in many cases the vessel wall repairs itself by rapid growth, the internal clot is absorbed, and the lumen partially or completely re-established.

Another factor in the natural arrest of hæmorrhage is the fall of blood pressure due to diminution in force of the heart's action, which automatically occurs in loss of blood, and is probably due to the cerebral anæmia.

The treatment of hæmorrhage consists locally in the immediate arrest of the bleeding at the point of severance of the vessel. In this respect remember that *both* the severed ends must be secured, as the *vis a tergo* is sufficient to cause considerable bleeding from that end of the vessel which is not bleeding so freely at the time of the wound.

Under certain conditions, such as the situation or nature of the wound, concealed hæmorrhage, or the surroundings in which the accident occurs, it may not be possible or advisable to explore the wound and expose the bleeding point. In such cases *pressure* just sufficient to overcome that of the blood stream should be applied, *locally* by a pad and bandage if possible, but if this does not suffice some form of *tourniquet* must be applied between the wound and the heart.

A tourniquet consists essentially of a constricting band in which is incorporated a pad to lie over the artery and some means of tightening it. Many forms are in use, but for surgical procedure the most satisfactory is the rubber bandage of Esmark or one of its many modifications, which allows of boiling to sterilise it. The tourniquet should never be applied to the bare skin, but over a towel or clothing, and so adjusted that the pulse in the limb is just obliterated. No tourniquet must be left unloosened for more than half an hour, or gangrene of the limb will ensue, and, inasmuch as the avascularisation and pressure produce intense pain, some form of sedative, usually morphia gr. ¼, is indicated. The tourniquet must be applied as near above the bleeding point as possible, so as to avascularise a minimum of tissue.

It will be seen that the application of a tourniquet is not without risk, and can be only a temporary measure.

It may be mentioned in passing that bleeding from a vein always can be stopped by pressure, combined with elevation of the limb above the heart; the application of a tourniquet to the lower limb for the arrest of hæmorrhage from ruptured varicose veins in the leg is, therefore, never necessary.

Pressure may be aided by the placing of small portions of damaged tissue, usually muscle, on the wound, which aid clotting by favouring fibrin formation, or by direct application of some finely-divided substance, such as sterile cotton wool.

A valuable adjunct to local pressure is the application of *styptics*, which help arrest the bleeding by hastening coagulation; of these the simplest is *very hot water* (130 to 160 degrees), which should be applied on cloths well wrung out in order to prevent scalding of surrounding tissues, which, as an additional safeguard, should be coated with vaseline or some other ointment. *Ice* or very cold water also may be used, but is not so efficacious.

The local application of *horse serum* is not of much value, but its injection (25 c.c.) into the tissues in the neighbourhood will assist clotting greatly, as will also *hæmoplastin* or *coagulin* Ciba in 2 c.c. doses by injection. Certain vaso-constricting substances, such as *adrenalin*, are of value if applied locally, especially in controlling capillary hæmorrhage; the efficacy of this drug is increased by the addition of a solution of cocaine hydrochloride, and is much used in nasal surgery. *Chemicals* have long been used as styptics, the chief being solutions of the *salts of iron and calcium*, *tannic acid*, *gallic acid*, *alum*, *etc.* They not infrequently cause sloughing of tissue, and their action may extend some way beyond the wounded area, both in causing clotting and sloughing. Their use, locally, therefore, is not advisable, but in cases of *internal hæmorrhage* the *injection of* 1 *c.c. of collosal calcium or iron* frequently will stop hæmorrhage apparently otherwise uncontrollable. Again, certain astringents, such as *turpentine*, *ergot*, *etc.*, which seem to act directly on plain muscle, are of value, but their use is frequently followed by gangrene and suppuration in the area.

The *cautery* at a dull red heat (if white hot it will sear through the vessel) or the electric diathermy apparatus is valuable in arresting hæmorrhage from large areas.

Rest is very essential in assisting the arrest of hæmorrhage, and for this purpose *morphia* (gr. ¼–½) may be given as an injection subcutaneously and the patient kept in the recumbent position with the affected area fixed in splints. Morphia, moreover, distinctly lowers the blood pressure by diminishing the force of the heart's action.

When definite bleeding points can be seen they should be grasped with pressure forceps which have serrated blades and a clip on the handles to hold the blades closed, such as Spencer-Wells forceps, or one of the many patterns existing; but on the whole toothed forceps are best avoided, as the teeth tend to tear away the vessel wall. The vessel should be picked up cleanly with the points of the forceps, which will obliterate the lumen and crush the walls. In the case of small vessels this often will suffice to arrest bleeding, especially if combined with *torsion*, *i.e.*, twisting the vessel round while held in the forceps. In the case of larger vessels, however, the forceps need to be left on for one or two days, before the clot is sufficiently organised to resist the blood pressure and prevent recurrence of bleeding.

In order to obviate the discomfort of having to carry the forceps for so long a time, it is customary, under aseptic or antiseptic conditions, to tie off the vessel behind the forceps, which are removed when the first hitch is tied, and, tension being kept upon the ends of the ligature during this removal to adjust it accurately to the tissues, the knot is then completed. For ligatures some pliable sterile material, such as catgut, silk or thread, is used.

Catgut is prepared from the intestines of sheep, soaked and scraped so that only the elastic submucous tissue remains. This is twisted into strands of varying thicknesses, and after hardening in a mixture of sulphurous and chromic acid, so as to resist too rapid absorption in the tissues, is sterilised by immersion for ten to twenty-one days in 1 per cent. iodine in potassium iodide. Catgut cannot be boiled. According to the time it has been hardened in acids it will resist absorption for from four to twenty-one days, or, if fully chromicised, indefinitely.

Silk and thread can be sterilised by boiling, and can be used from gossamer to any thickness. When not in use they should be kept in spirit and boiled immediately before use for two minutes. Such ligatures are not absorbed:

they should therefore be used as fine as possible, and the ends of the ligature cut close to the knot, or else the fibrous tissue with which they become encapsuled may form a painful nodule in the tissues, especially near the skin.

The effect of ligature is to divide the inner and middle coats of the vessel which curl up and obliterate the lumen; in the case of very large vessels, where the blood pressure is so high as to risk rupturing the adventitia, the inner coats should only be approximated; this is best achieved by the "stay knot" advocated by Ballance and Edmunds, which consists in tying a double hitch (*surgeon's knot*) in each of two ligatures side by side, and then completing the knot by tying the four ends together.

(2) **Reactionary Hæmorrhage** is the term applied to recurrence of bleeding from a wound within twenty-four hours of hæmostasis. It may result from (1) slipping of an insecurely tied ligature, or (2) the recovery to normal of the patient's blood pressure causing bleeding from vessels overlooked at the previous operation, the clot having now been forced from their mouths. It is serious only when occurring in deep situations, such as in the abdominal cavity after operations, as it gives rise to internal hæmorrhage. The treatment is as for primary hæmorrhage.

(3) **Secondary Hæmorrhage** is used to indicate any bleeding from a wound after the first twenty-four hours. *It is always due to infection* in the wound; this results in softening of the vessel walls, which give way under the blood pressure. It commonly occurs eight to ten days after the infliction of the wound; there is frequently a slight bleeding about twenty-four hours before the real hæmorrhage occurs. It must be remembered that as the vasa vasorum, the little vessels nourishing the artery, run obliquely with the blood stream in the vessel walls, that part of the vessel in and beyond the ligature is dead and therefore very liable to infection, and the resulting slough may be cast off on the proximal side of the ligature, the infected clot be forced out, and the reopened vessel bleed again freely.

Treatment. The treatment of such cases is to lay the wound open freely, expose and ligature the bleeding vessel, which may be a difficult task owing to the ligature cutting through the softened vessel wall, and clean and drain the wound. It may be necessary to expose and ligature the vessel at some distance from the wound, but this should be avoided if possible, as the additional avascularisation entailed favours the spread of the infection. It is, however, wise to keep a tourniquet lightly round such limbs so that it can be tightened in the event of recurrence of the hæmorrhage. Very occasionally amputation may have to be resorted to in the case of a septic wound in a limb. Secondary hæmorrhage, which was a terrible menace to surgery in pre-Listerian days, has now, fortunately, almost vanished under asepsis and antisepsis; it is most commonly seen in the field after gun-shot wounds, and was very common during the late war.

SHOCK AND COLLAPSE

No treatise on injuries would be complete without dealing with the treatment which is necessitated by the loss of fluid from the body and the collapse induced thereby, and it is in this connection necessary carefully to differentiate between the two conditions of *shock* and *collapse*.

Shock is due to over-stimulation of nerve centres such as may be produced by any sudden injury or violent emotion, producing a temporary inhibition of their function. The consequent upset to the general body system results in a temporary loss of consciousness (*fainting*), so that the patient falls to the ground, with a rapid irregular heart action and shallow and quick respiration. The condition is not in itself serious, but if left untreated is a potent cause of collapse.

The *treatment* is to be directed to stimulating the inhibited centres and tiding over the period of inactivity. Such drugs as strychnine (gr. $\frac{1}{35}$ hypodermically), digitalin (gr. $\frac{1}{100}$ hypodermically) may be given, and cutaneous stimulation by heat, cold or slapping resorted to, the patient being placed in the recumbent position, with a good supply of air.

Collapse (surgical shock) is a serious condition resulting from the exhaustion of nerve centres either from continued over-stimulation as from pain, from anæmia as in loss of blood from hæmorrhage or escape of plasma from the capillaries into the tissues, or from the entrance into the circulation of toxins. The toxins in the case of injury can be shown to be products of incomplete disintegration of the protein molecule, such as histamine and allied bodies (Dale and Laidlaw), and also can be shown to be produced from damaged muscle (Cannon and Bayliss), while the application of a tourniquet above the damaged tissue may prevent collapse occurring. In cases of disease the collapse is due to the toxins derived from the causative micro-organism circulating in the blood stream.

More recent work has tended to cause a swing-back to the original theory that a prolonged stimulation or over-stimulation of sensory nerves, with subsequent depression of the lower cerebral nerve centres and resulting fall of pressure, plays a greater part in the causation of collapse than the liberation of toxins from damaged tissue. Again, the sympathetic and parasympathetic nervous systems undoubtedly play their part in the production of surgical shock.

From the foregoing it will be seen that the conditions produced by prolonged surgical interference—over-stimulation of sensory nerves, loss of blood and damage to tissue—are ideal for producing serious collapse. Hence the name *surgical shock*, which is given to this condition by many authorities. The patient may be semi-conscious or unconscious, the *respirations* are rapid, shallow and sighing in character, and in severe cases may assume the rhythmical type known as "Cheyne-Stokes," where the breathing gradually diminishes, ceases for a short period, and then gradually increases again, this cycle being repeated. The *heart* is rapid and irregular, the pulse almost imperceptible, blood pressure low, the *skin* blanched and clammy, and the patient feels cold. The pupils are dilated, and there may be incontinence of urine and fæces due to relaxation of the sphincters. The cheeks are sunken and the subcutaneous tissues lax from absorption of fluid from them to make up for that lost from the hæmorrhage. Such a patient, unless treated promptly, will die rapidly, and *treatment* must be devoted to resting the exhausted centres and restoring vitality. Any direct stimulation of the exhausted centres by such drugs as strychnine is to be avoided, as such treatment may be compared to flogging a tired horse, the result being a momentary flicker of energy followed by complete exhaustion. The patient should be well wrapped up in the recumbent position, and warmth applied by hot water bottles, etc., care being taken not to produce great sweating. The limbs may be bandaged, which serves both to conserve body heat and keep the blood for the vital centres; for the same reason the lower end of the couch may be elevated on chairs or blocks. Stimulants should be given to keep up the nutrition of the heart muscles; of these by far the best is alcohol, which may be given in the form of neat brandy—rubbed on the lips when the patient cannot swallow. Camphor, 10 minims, of a solution 20 per cent. in oil or coramine may be injected intramuscularly, while caffeine sodium salicylate, grs. v., is valuable. Injection of pituitrin, 1 c.c., or ergotin, ♏ xv., both of which drugs raise the blood pressure by vaso-constriction, are very valuable adjuncts to stimulation of the heart muscle. It must be remembered that prevention is better than cure, and that inasmuch as previous hæmorrhage, exposure to cold, exhaustion, pain, rough handling or prolonged anæsthesia all aggravate and cause shock and collapse, these must be avoided, or minimised as far as possible. Thus in the case of accidents morphia should be given, burns or wounds covered, and the patient kept warm. Fluids (see below) should be given by mouth, intravenously, subcutaneously, or rectally if they can be retained, and constitute the chief treatment in collapse.

N.B. In the case of collapse due to hæmorrhage, stimulants (or infusion) should never be given until the bleeding has been arrested, as they otherwise increase the loss of blood and frequently, by stimulating the heart's action and increasing blood pressure, restart bleeding from vessels already stopped by clot.

Respiration may be assisted by the administration of oxygen, and should it cease while the heart is still beating, artificial methods may be resorted to with advantage.

The chief methods of **artificial respiration** in vogue are:—

(1) *Sylvester's Method,* in which the patient is laid on the back with the head turned to one side, and after exploring the back of the throat with the finger to see it is clear of any foreign body, the tongue should be pulled out. The arms, grasped at the elbows, are first extended above the head and then pushed down on to the thorax, thus compressing it—a manœuvre to be repeated twenty times a minute.

(2) *Schäfer's Method.* In this method the patient is laid on the face and a pad placed in the epigastrium; the operator, sitting astride the patient's buttocks, then presses on the lower ribs, and alternately relaxing and making pressure about twenty times a minute, promotes the entry and exit of air into the lungs. This method, which permits of the emptying of the air passages of water, mucus, etc., is the method of choice in the restoration of the apparently drowned (see Vol. II., Chapter XI.).

(3) Various automatic machines and pumps such as the *Drinker* apparatus, have been devised which may be useful for prolonged artificial respiration.

In cases where much fluid has been lost, *i.e.*, by hæmorrhage, nature will try to replace this by absorption of lymph and tissue fluids into the circulation and the fluid can be more rapidly and advantageously replaced by the introduction into the vessels of some sterile solution isotonic with the blood. Even in cases where no blood has been lost, there is an apparent loss of blood in the systemic circulation, with consequent cerebral anæmia, due to the flooding of the greatly dilated vessels in the splanchnic abdominal circulation, and in these cases introduction of fluid into a peripheral vessel is almost equally beneficial. Dale and Lewis have shown that the capillary tone is independent of that of the rest of the vascular system, and further that in collapse this capillary tone is much diminished, so that the system becomes flooded with blood, which owing to the feeble heart action tends to lie stagnant in the capillaries. When it is realised that the volume of blood in a working muscle is roughly 500 times that in the same muscle at rest, it will be realised readily what a serious effect this generalised flooding of the capillaries in collapse will have on the blood pressure, and how great a menace it constitutes to the very life of the patient.

The fluid used may be blood obtained from another person (the donor), whose blood grouping is not antagonistic with that of the patient—this process is known as **transfusion**—or a sterile saline solution may be used of the strength of one drachm of salt to a pint of water; or a solution of 6 per cent. gum arabic or acacia in saline, which by its viscosity remains longer in the vessel lumen before transfusion to the dehydrated tissues, and so produces a more lasting effect than pure saline solution—this is **infusion,** but it is not of great value, as the fluid rapidly transudes into the tissues, which become waterlogged, and may cause death by acute œdema of the lungs.

The solution should in all cases be warmed to just above blood heat (100° F.) and be introduced under aseptic precautions into a superficial vein; stimulants, such as brandy ʒii to a pint, or vaso-constrictors, *i.e.*, adrenalin ʒi of $\frac{1}{1000}$ solution per pint of saline, may be introduced with advantage into the solution to be infused. As a general rule not more than one or two pints of fluid should be introduced for fear of pulmonary œdema resulting.

Infusion may be carried out either by the subcutaneous puncture of a vein with a hollow needle attached by about 2 feet of rubber tubing to a receptacle of saline solution—the whole being sterile; or an incision may be made and the vein, usually the median basilic, exposed, ligatured below, opened, and a blunt cannula inserted, connected as in the case of the needle. Care must be taken that saline is running through, whichever method is adopted, in order to *preclude the entrance of air into the vein.* Should such an accident occur, the air may be churned up in the right heart and so impede the circulation that death may result; such an untoward occurrence is, however, only likely to occur where large quantities of air have been introduced.

TRANSFUSION

In addition to the treatment of shock and collapse, other indications for the use of transfusion of blood are :—

(*a*) After hæmorrhage.

(*b*) In hæmophilia, purpura, pernicious anæmia, aplastic anæmia, marked sepsis, septicæmia, typhoid, the toxæmia of burns, etc.

(*c*) Before operations on jaundiced, anæmic, or toxic patients.

(*d*) In infants for melæna neonatorum, marasmus, shock, burns and diarrhœa and vomiting.

(*e*) Transfusion with an immunised blood may be performed (*immuno-transfusion*), but is not usually of great value.

The technique of transfusion depends on the method chosen. In any case the first step is to ascertain the blood group of the recipient, and then find a suitable donor. Blood sera fall into four groups in regard to their action in coagulating or hæmolysing the red cells of the donor, and it is essential that the serum of the person transfused shall not belong to a group which will produce destruction of red cells of the donor in the vessels of the recipient. The action of the serum of the donor on the recipient is for practical purposes negligible, as the quantity transferred is so very small in relation to the bulk of the recipient's blood.

The group characteristic, as far as is known, is inherited by Mendelian laws, the final group to which a child belongs usually being determined by the age of one.

Therefore no transfusion must be performed unless the Group of both Donor and Recipient are known.

These groups are :—

(Moss) I.	Universal Recipient now known as (International)	AB
II.		A
III.		B
IV.	Universal Donor	O

The groups can be ascertained by testing a drop of the patient's blood against drops of known sera of Groups II. and III., when the following reactions will occur :—

Patient belonging to :

AB Group I. Precipitation with both drops
A Group II. Precipitation with Group III. serum.
B Group III. Precipitation with Group II. serum.
O Group IV. No precipitation with either drop.

In other words, a patient in :—

AB Group I. can receive blood from a donor Group I. (AB), II. (A), III. (B), or IV. (O).
A Group II. can receive blood from a donor Group II. or IV. (A or O).
B Group III. can receive blood from a donor Group III. or IV. (B or O).
O Group IV. can receive blood from a donor Group IV. (O).

If transfusions are to be repeated it is as well to use different donors, as sensitisation is sometimes established towards one. Though 500 to 750 c.c. can be withdrawn without effect from a healthy donor, it is wise for a donor not to give blood more than three times a year.

There are two methods of transfusion: (1) *The Direct,* where either the artery of the donor is cut and directly anastomosed to the vein of the recipient —a method not much in vogue—or transferred by means of a syringe with a two-way tap and double needle connections; (2) *The Indirect,* where the blood from the donor's artery is led into a specially prepared glass vessel (Kimpton's

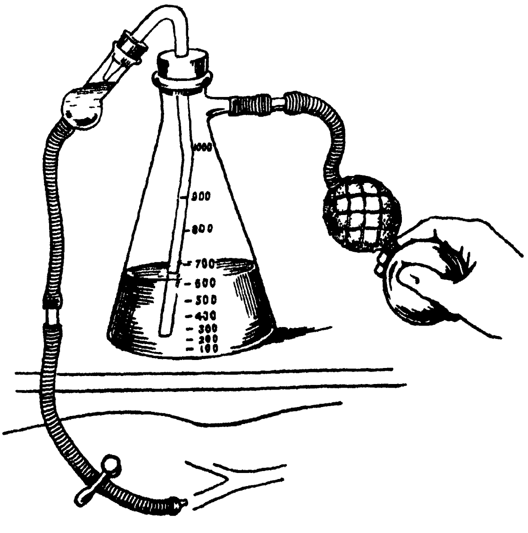


FIG. 12. Transfusion of blood.

Tube) greased with sterile paraffin to prevent clotting, and thence transfused into the patient's vein.

The method commonly in use is the *Citrate method*, where the donor is bled the required quantity into a sterile vessel containing sodium citrate in sterile water to prevent clotting. For one pint of blood 50 c.c. of water with 2·5 gm. (37 grs.) of citrate are needed. This mixture is then infused into a vein through an infusion cannula.

Stored Blood and Complications. The advent of the war has called for a large reserve of blood and while in some countries this is provided from stored cadaver blood, and to some extent by placental blood, in this country the need has been met by providing a large number of group O donors who are bled regularly to form a reserve (blood bank). The blood is stored and conveyed in refrigerators ready for use and must on no account be more than fourteen days old otherwise ill results from incompatibility due to laking will be seen in the recipient. These ill-effects vary from immediate breathlessness or faintness, to severe clotting, rashes, jaundice with hepatic atrophy, rigors and even death, and the advent of any untoward sign or symptom during any blood transfusion therefore calls for its immediate discontinuance.

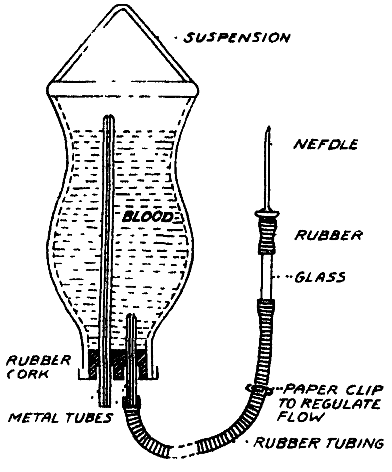


FIG 13. Blood transfusion apparatus.

To avoid these troubles and loss of blood, this stored blood can be whipped or allowed to separate and the serum evaporated to a brownish crystalline mass, which contains most of the hæmoglobin and which can be stored in a sterile flask. Sterile distilled water can be added and the whole heated and given as a transfusion with excellent results. A universal pattern flask with a rubber cork which can be penetrated by sharpened metal tubes, and protected by a detachable metal cap has been designed by the Royal College of Surgeons Transfusion Unit and is illustrated in Fig. 13.

Continuous Intravenous Drip. By this method saline, glucose and blood can be given continuously for prolonged periods and with little or no danger of waterlogging the patient as the drip rate can be modified at will; ordinarily the drip is set from thirty to fifty a minute by adjusting the control (see Fig. 13).

In small children the blood may be injected through the anterior fontanelle into the longitudinal sinus, 15 c.c. of blood per pound of weight being given.

The amount of blood to be transfused varies from about 500 to 1,000 c.c. in adults and 50 to 150 c.c. in infants. The operation is often followed by a slight chill and fever.

Though really making use of a " modified blood," the citrate method has great advantages, for there is no contact between donor and recipient, the blood can be transported to a distance, and the method is not contra-indicated in hæmophilia. Two special forms of transfusion are sometimes employed :—

(*a*) ***Exsanguination transfusion***, where blood is drawn off first from the recipient, to be replaced by fresh healthy blood from the donor. This is useful in coal-tar poisoning, severe toxæmias, septicæmia, etc.

(*b*) *Immuno-transfusion.* In these patients the donor is given a single large dose of staphylococcal vaccine. A rapid increase in the protective bodies follows which reaches a maximum in four hours and is non-specific, *i.e.*, is protective against any organism. It is usual to give the donor one dose of 1,000,000,000 staphylococci and to transfuse in four hours, not giving more than 500 c.c. of blood.

Before closing this section on hæmorrhage attention must be directed to certain conditions in which bleeding is very free, even from small wounds, and where the capillary oozing may result in death of the patient owing to the loss of power of clotting by the blood. It will be seen at once that such conditions are very serious, as in the absence of clotting even the most minute wound in time will cause the death of the patient from continued hæmorrhage. These conditions are fortunately rare and are enumerated below.

Hæmophilia is a hereditary blood disease transmitted through the females, and in nearly all cases manifesting itself in the males of the succeeding generation, the females being usually free from the disease, but capable of transmitting it to the next generation and so on. It is essentially a familiar disease, and most families so affected will always know they are "*Bleeders.*" It is of interest to note that there appears to be a regular cycle of activity of the disease, the patient being quite normal between times and capable of being operated on without fatal results from hæmorrhage, while if he reaches the age of twenty-five or so the condition tends to improve and even pass off. Very slight trauma in the active period will result in huge internal hæmorrhage or severe and uncontrollable external hæmorrhage. It is clear that *no operative procedure whatever* should be undertaken in such cases. In some instances it is found that the time of blood clotting is perfectly normal, and it appears in those cases as though the disease were due to abnormally fragile capillaries.

In *scurvy*, and for some time after its cure, a similar condition exists in regard to absence of blood clotting, and the same is true in cases of *old-standing jaundice*, where the bile salts delay clotting very considerably; the same condition is also present to a lesser extent in advanced anæmia, blood diseases, and septicæmia, where hæmorrhages may occur spontaneously during the disease.

Purpura is a condition usually associated with deficiency of blood platelets in which severe hæmorrhages may occur spontaneously. If the blood count, apart from platelets, is normal, the proper treatment is splenectomy (Vol. II., Chapter XVIII.).

Treatment consists in avoiding all trauma and operative interference—especially remember never to extract teeth. If hæmorrhage is in progress, the local application of tissue or blood clot from a normal individual may be tried or the injection of 25 c.c. of normal horse serum or 2 c.c. collosal calcium, while *Russell's Viper Venom* in solution may be applied to the bleeding surface, the dressing being bound on tightly and kept in contact with the raw area for at least an hour under considerable pressure. Should these fail, as is often the case, a tourniquet may be tightly applied proximal to the bleeding point if in a limb and left on till gangrene occurs. Blood transfusion, if possible from a donor of the same group and without citrate, may be of great benefit both in improving the patient's general condition and in arresting the bleeding. Vitamin K appears to be beneficial.

Hæmophiliac joints are dealt with in Chapter XIX., p. 624.

BURNS AND SCALDS

Burns are produced by the application of dry heat to the body surface, whereas the application of moist heat, *i.e.*, steam, results in a **scald**. The two conditions are very similar in appearance in their milder forms and are usually described together—their results may be compared to those produced respectively by roasting and boiling. Dupuytren originally described *six degrees of burns and scalds*, and this classification is the one usually adopted at present:—

(1) Scorching and superficial congestion of the skin, which will appear *reddened*, without any tissue destruction. Should the scorch be frequently repeated, the skin becomes chronically thickened and pigmented as seen in "Erythema ab Igne," a condition of pigmentation met with in the legs of persons constantly before a fire, such as stokers.

(2) In this degree the cuticle is raised from the cutis vera and *blistering* results; such blisters may coagulate *in situ* or burst and expose the red and tender skin beneath.

(3) The cuticle is destroyed and also the superficial part of the true skin, but the interpapillary processes, with their sensitive nerve endings, are thus left exposed; hence burns of this degree are *very painful* and accompanied by great collapse. They are, indeed, the *most fatal* variety from this cause, and a very grave prognosis should be given if they are extensive, burns involving the neck, trunk or both limbs being usually fatal, more especially if occurring in young children. The sweat and sebaceous glands are not destroyed and healing will thus be rapid, epithelialisation occurring from all over the burnt area and normal skin being quickly reformed, *no contractures or deformity* resulting.

(4) The whole thickness of the skin and part of the subcutaneous tissues are destroyed.

(5) Muscles are also involved in the destruction.

(6) The whole limb is charred or disorganised.

In the last three cases the collapse is often surprisingly small owing to the total destruction of nerve endings, but serious contractions usually result from the scarring consequent on healing.

Clinical Features. The local signs of a burn or scald have been dealt with under the classification, but it must be remembered that the surface may be obscured by the presence of charred clothing. Subsequent to the stage of destruction, separation of the dead and burnt parts occurs, and this is accompanied by all the signs of inflammation, and inasmuch as, unless the cleansing of the area has been thorough, *infection is very frequent*, suppuration indicated by a free purulent discharge is often present. Later, when the sloughs are separated, a clean ulcerated surface remains (*q.v.*), which heals by granulation unless skin grafted early.

The constitutional signs are often severe. *Shock and collapse* are particularly marked in lesions of the third degree and not infrequently fatal during the first few hours. Later if sepsis occurs there is considerable absorption of toxins from the damaged tissues, manifested by a *temperature, rapid pulse* and *flushed face*, and occasionally *delirium*, and often *pulmonary complications*. These latter, the commonest of which is a *septic broncho-pneumonia*, are very common in *children* and old persons, being serious and often fatal complications. The toxæmia may come on very suddenly, and is thought to be due to the pain, loss of fluid and absorption of proteins and possibly of histamine from the burnt skin; later still, after a day or two, severe sepsis and formation of pus may occur.

Another interesting but rather infrequent sequela is *duodenal ulcer*, which, when present, occurs in the second part of the duodenum near the ampulla of Vater: it does not appear to be so common as formerly, and is most probably due to vascular thrombosis, rather than elimination of toxins from the liver *via* the bile duct, these toxins being absorbed from the septic and infected surface, a fact borne out by the rarity of the lesion now that burns are kept rigorously cleansed.

Death from burns in the initial stages may occur from asphyxia, due to the smoke and noxious gases resulting from the conflagration, or result from shock, or the subsequent onset of collapse, which is a common cause of death. *Shock*, due to the fright, is always present, but death seldom occurs from this, and it is best combated by opium, which should be given freely. *Collapse* is very marked, due partly to suffocation, but far more to severe pain, absorption of histamines from the damaged tissues and escape of fluids, which is enormous from the burnt area. In the later stages, septic bronchopneumonia is by far the commonest cause of death, and in order to guard against this all third degree burns in children should be, if possible, admitted to an institution, or very carefully nursed at home in one room at a uniform temperature, but with plenty of fresh air. A fatal result is therefore not unusual, especially in extensive third degree burns; it has been shown to occur most frequently in from twelve to forty-eight hours and to be due to loss of fluid and absorption of histamine bodies.

It cannot be urged too strongly that once adequate first-aid measures, in the form of tannic acid (or tea) compress, warm drinks and warmth, with if possible opium, have been applied, it is far better, when possible, to allow the patient to rest quietly where he is for some twenty minutes before moving him to hospital for further treatment. It must be realised that the mortality from burns is nearly three times as high as from scalds, and the prognosis correspondingly grave.

FIG 14. Burns. Tannic spray to face and compresses and splints to arms.

The *treatment of burns and scalds* resolves itself into local treatment for the burnt area and general treatment directed to combating the shock and collapse.

(*a*) *Local treatment* has three ends in view: firstly, *the coagulation of the damaged tissues* to prevent collapse from absorption of histamines and loss of fluid; secondly, the *allaying of pain*, and so lessening a potent cause of shock and subsequent collapse; and thirdly, the *cleaning of the surface*, with a view to preventing infection. With these ends in view, it will be realised that treatment (especially first-aid) with such substances as oil and flour, carron oil and washing soda, though admirable in relieving pain largely by their adhesion to the surface preventing access of air, fails signally to achieve, and indeed hinders, the other aims of treatment.

An excellent lotion, both for a first and subsequent dressing, is a 2 per cent. aqueous solution of *tannic acid,* to which 1/2,000 perchloride of mercury or hexylresorcinol can be added with advantage for first-aid purposes, as it is sufficiently antiseptic to allow the lotion to be made up with tap water and applied on clean linen ; no other antiseptic has proved as satisfactory. When tannic acid is not available, cold tea can be substituted for first-aid treatment The 2 per cent. tannic acid acts by coagulating *all* the damaged tissues, as it is absorbed rapidly by these, so preventing collapse and pain ; therefore the earlier it is applied after the injury the better for the patient. At the same time Tinct. opii or morphia should be given freely, for when the patient is finally "dressed," a proceeding which must not take place till the opiate has taken full effect, a very thorough cleansing of the burnt area is necessary if subsequent infection is to be avoided ; this should be performed by thorough washing with soap and warm water applied with a swab (never with a nail brush), especial care being devoted to the edges of the area. All blisters and dead and raised skin must be removed and the area ultimately swabbed over with ether to remove all natural or applied grease.

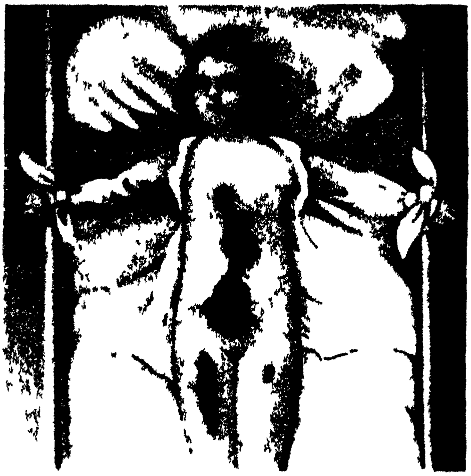


FIG. 15 The dark eschar produced by tannic acid spraying of a scald. Electric cradle and bed-clothes removed. Child's hands secured to prevent picking the scab.

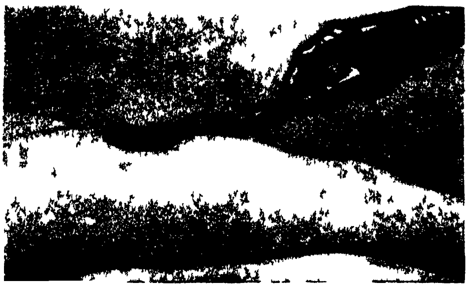


FIG. 16. Separation of scab in ten days, showing epithelialisation beneath.

The final application of tannic acid, 2 per cent. solution, is then made : (1) As a "*Compress*" by applying several layers of gauze or lint soaked in the solution, these are laid evenly on the area and bandaged lightly but firmly in position. The compress is left undisturbed for two or three weeks and then removed, when the scab comes away, leaving epithelialised tissue in the case of first, second and third degree burns, and a clean granulating ulcer in more severe cases. (2) With a "*Spray,*" a method applicable only in institutions, but preferable in areas such as the perineum, groin, neck, etc., where bandages are ill-tolerated. An electric cradle is placed over the child, and 2 per cent. tannic acid solution sprayed on hourly for twelve to eighteen hours. This dries, forming a dark dry crust which separates in about fourteen days. On the face care must be taken to protect the cornea which may be damaged by tannic acid.

Should sepsis occur during treatment, or the case be seen only when septic, thorough cleansing should be carried out and a new tannic acid dressing applied, when the results are almost always satisfactory. Inasmuch as the sepsis is usually streptococcal in origin, *sulphanilamides* should be given in all cases or indeed is a valuable prophylactic if administered from the first in all burns.

Another and less satisfactory method of treating burns and scalds is by a 1 or 2 per cent. aqueous solution of picric acid, which produces only a superficial coagulation of the tissues, and therefore still allows collapse from absorption of histamine, and also permits loss of fluid. Picric acid is, moreover, absorbed, and is liable to give rise to toxic rashes and albuminuria. It is, however, still used extensively and gives much better results than grease.

Some authorities advocate a rapid coagulation by painting the burnt area with 10 *per cent. silver nitrate* before tanning so as to obtain a harder eschar, while others paint the edges with 1 *per cent. aqueous gentian violet* solution to diminish the risk of sepsis and increase coagulation; both methods have their uses.

Recently Bunyan and others have advocated enclosing the burnt area in a casing of silk and washing frequently with hypochlorites in warm saline, a method which is painless, but needs elaborate hospital technique; these baths are also used in cases of sepsis supervening in burns.

Crude cod liver oil and vegetable oils have their advocates who claim excellent results; there seems to be a membranous formation where protein and these oils meet, so that some coagulation appears to be produced. Paraffin waxes which were at one time popular produce no coagulation, permit of severe sepsis and have nothing to recommend them as a treatment.

In deep lesions, whatever treatment is used, splintage must be resorted to for the prevention of possible deformities, and the resulting ulcer will need skin grafting or treating with some astringent lotion, of which the best is

℞	Zinci Sulph.	grs. xx.
	Aluminis	grs. xx.
	Glycerini	aa O i.
	Aquæ	

The mortality of burns and scalds has been much diminished by the tannic acid treatment, as is shown by the appended mortality table covering five-year periods.

Treatment.	Burns.	Scalds.
Oil, etc. . . .	39 per cent.	18·8 per cent. mortality.
Picric, 1 per cent. .	15·5 ,,	7·0 ,, ,,
Tannic, 2 ,, .	4 ,,	1·7 ,, ,,

ELECTRIC BURNS

These are more common than formerly, and their characteristics differ sufficiently from heat burns to merit a separate description. They fall into three classes:—

(1) **Lightning Stroke,** which in many cases is instantly fatal. In other cases the patient suffers from severe shock, though there may be no marks of external injury, or there may be erythematous patches or large areas of staining often arborescent, and corresponding to lines of moisture on the skin. These usually fade in a day or so. In other cases the results resemble those seen in ordinary burns, *but the healing is extremely slow,* as indeed in all forms of electric burns.

(2) **Electric Burns**, usually from "commercial" current, most often occur in electrical employees; the lesions, which vary from erythema to complete charring and destruction, are most marked at the entry and exit points of the current. Great and persistent shock and collapse accompany such burns, and although there may be no pain at first, after twenty-four hours this is great and continuous. Healing is very slow and often accompanied by extensive sloughing—hence skin grafting to prevent contractures is often practised when the area is clean.

(3) **X-ray and Radium Burns** are now rare and occur commonly as a result of over-exposure in treatment. They fall into two classes, the *erythematous* and the *ulcerative* :—

(*a*) *The erythematous type* starts as painless, red patches, very similar to those seen after exposure to the sun (*erythema solare*); this is painless, but accompanied by intense itching, and usually only appears from ten days to three weeks after an exposure to an overdose on one occasion. Later the skin becomes hard, dry and cracked, and finally desquamates, the hair is lost, and the nails become brittle if the hands are affected; sensation, especially of touch, may be impaired; the itching persists and is often very distressing. This condition is frequently described as *X-ray dermatitis*, and is similar to that seen after any chronic irritant, *i.e.*, the form met with from exposure to formalin, or overdose of radium emanations. The condition is very persistent, often relapses after apparent cure, and tends to pass into a condition of epithelioma or X-ray cancer. Tannic acid compresses are a soothing and efficient dressing.

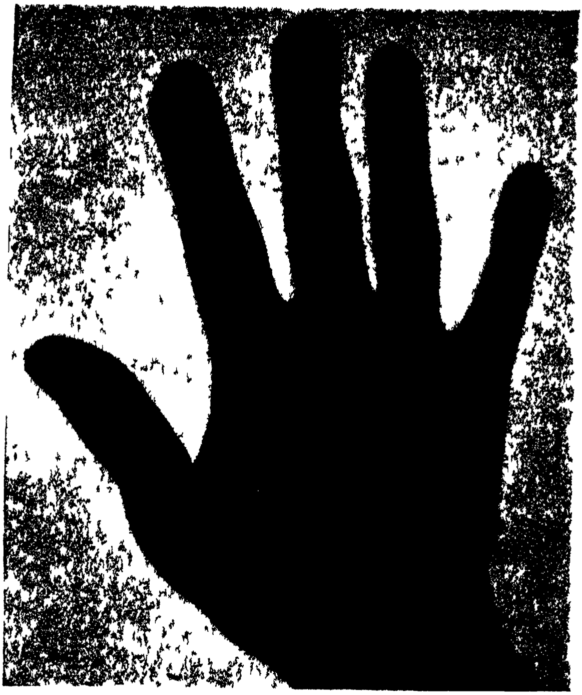


Fig. 17 X-ray dermatitis with multiple epitheliomata.

(*b*) *The ulcerative type* usually occurs after exposure for long periods to the rays, and often comes on within a week of exposure, but may be much longer delayed. The first sign is a painful erythematous patch, which soon blisters and breaks down, leaving a raw, painful area. This ulcerated surface sloughs and spreads both superficially and deeply, until muscle may be exposed. The sloughs separate very slowly, and the whole condition is chronic and painful to a degree which often calls for morphia in order to alleviate it. Here, again, the healing process is very slow. In all cases skin grafting is of great value in hastening the process. A similar condition may result from over-exposure to radium emanations, which thus will be seen to have similar results on the tissues to the X-rays.

Burns from acids and caustics are usually very painful, accompanied by extensive sloughing, heal very slowly, and cause considerable contraction owing to the destruction caused by the corrosive action of the fluid. They are commonest on the hands and face, in which latter case damage to the eyes is not infrequent, and always must be carefully examined for at the time of the injury. *Treatment* consists in efficiently neutralising the corrosive chemical, and then applying a tannic acid compress.

Frost-bite, which results from the action of extreme cold on the exposed tissues, is very rare in this country ; the nose and ear are commonly affected, but the distal portions of limbs may be destroyed in severe cases.

It may arise either from the *direct effect of cold* on the tissues, when the *process is painless* and the waxy appearance of the affected tissues is usually first noticed by onlookers, or from the *inflammation consequent upon thawing* of the part which, though frozen, has not been immediately killed, this variety being *extremely painful*. The pathology of this latter condition is that the prolonged anæmia from vaso-constriction so depresses the vitality of the tissues that the readmission of the circulating blood is followed by an acute inflammatory process, the exudate resulting being so excessive as to compress and thrombose the damaged vessels. For this reason the restoration of vitality in a frozen part should be gradual, such as by rubbing with snow, and never by approaching near a fire. Under this latter group of frost-bite is included *Trench-foot*.

Chilblain (Erythema Pernio) is a common malady affecting the fingers, toes and ears of some persons. It occurs in the winter months and is the result of impaired circulation due to damp and cold. The skin appears dusky, red and shiny and the area looks full and tense, there is an itching or smarting in the part, and in severe cases areas of skin may go gangrenous and appear black, the slough, on separating, leaving an ulcer which is usually very slow in healing (Broken Chilblain, Chapter IX., p. 247).

There are many popular remedies for chilblains, but the most effective is a short exposure to ultra-violet rays or in severe or obstinate cases to X-rays. In severe cases associated with Raynaud's disease excision of the inferior cervical ganglion often eases the condition for many months, if not permanently.

Sunburn (Erythema Solare) is now frequently seen and varies from an erythematous blush to severe blistering, in which case general symptoms may be severe, and consist in high temperature, headache, and even delirium or coma. Locally calamine lotion with which 1 per cent. tannic acid has been incorporated may be dabbed on with great benefit in mild cases, while in severe ones where blistering has occurred 2 per cent. tannic acid solution should be applied as a compress or by spray, while general symptoms must be dealt with by rest in a cool room, with ice bandages to the head and spine, cold water enemata, and venesection in severe cases.

CHAPTER V

NON-SPECIFIC INFECTIONS

Local. *Suppuration, Abscess, Ulceration, Cellulitis, and Erysipelas.*
General. *Pyæmia, Septicæmia, Sapræmia.*
Temperature in its relation to Infection in Surgical Diseases.

As has been pointed out in the preceding chapter, microscopic death of tissues as the end of successful bacterial infection results in a process known as **suppuration,** the results of which are the formation of an emulsion of bacteria and tissue cells in the blood serum, known as *pus.*

Pus, the constitution of which has been already discussed (see Chapter III., p. 26), is formed only by the action of certain organisms in the tissues, and will vary in its characteristics, colour, odour, etc., according to the causative organism in each case. It must be remembered that the pus in any lesion may be the result of the action of many organisms at once, in which case it is spoken of as the result of a *mixed infection.*

The chief pyogenic organisms are :—

Staphylococci, perhaps the commonest cause of suppuration. The resulting pus is usually thick, creamy and odourless, and usually localised as an abscess.

Streptococci, also common organisms, met with more particularly in the diffuse forms of suppuration, cellulitis and erysipelas ; they produce a thin irritating sero-pus, usually known as " ichorous."

Diplococci. Pneumococcus (pneumonia), gonococcus (gonorrhœa), meningococcus (meningitis), and micrococcus catarrhalis (common cold) are all common pus-producing organisms in this group.

Bacilli coli-typhoid, a group of intestinal organisms, are also met with as a cause of pus formation ; although the pus formed in pure culture is odourless, yet their close association with other intestinal organisms, such as *B. proteus vulgaris,* which produce aromatic phenol compounds, renders the odour of the resulting pus very offensive when, as frequently occurs, a mixed infection is present.

Bacillus pyocyaneus, also an intestinal inhabitant, produces pus of a blue-green colour, and an infection which frequently terminates fatally.

Bacillus tuberculosis, Spirochæta pallida and *Streptothrices,* by the action of their toxins on the tissues and their obliteration of blood vessels, produce a chronic suppuration, the pus being of a somewhat different type from that seen in the acute suppuration of the foregoing organisms. The difference lies mainly in the type of cell met with ; those in acute suppuration are polymorphonuclear leucocytes, and in chronic varieties lymphocytes and giant cells. These organisms form a group producing lesions rich in granulation tissue and called *infective granulomata,* under which heading they will be discussed (see Chapter VI., p. 101).

Before proceeding to a description of the various suppurative lesions produced by these organisms in the tissues it is necessary to explain two terms used in connection with their infection, namely, *specific* and *non-specific.*

By a **specific infection** is meant one *produced by one particular species* of micro-organism only, as in *tetanus, tuberculosis, syphilis,* etc., where the resulting lesions are pathognomonic of the ætiological organism, though they may show great clinical differences at different stages of the infection.

This term has latterly become somewhat elastically applied to the *similar lesions produced by groups of organisms,* as in *actinomycosis,* which we now know may result from the infection of many varieties of *streptothrices.*

" Specific disease " is a term often used colloquially to mean syphilis, but this is entirely an unscientific use.

Suppuration, which is the result of the action of many varieties of bacteria and has no definite ætiological clinical characteristics, is spoken of as *non-specific,* although in many cases the bacteriologist easily can isolate a specific causative organism, and it is probable that with increasing knowledge and improved laboratory facilities future work will result in a further reduction in those cases of suppuration still included in this *non-specific group.*

At the present time the term **non-specific infection** is applied only to those lesions which result from the invasion of the body tissues by the *Staphylococci* and *Streptococci,* although clinically the lesions produced by these organisms may be indistinguishable from those resulting from infection by specific organisms.

Whether or no the results of the invasion of the body by micro-organisms remain localised to the area of invasion or disseminate throughout the host is purely a question of the ability of the tissues at the point of infection to resist the bacterial toxins by an adequate inflammatory reaction. Should this reaction be all-sufficient, *resolution may occur,* as has been pointed out previously (Chapters II. and III.), without that death of tissue which leads to suppuration or even gangrene in the area. Inflammatory products in neighbouring tissues may *localise this suppuration* either at once, when *an abscess* results, or more gradually overcome the toxins, when *cellulitis* is present; but these attempts at *localisation may fail,* and in that case the organisms or their toxins gain entrance to the blood stream and so travel to distant parts of the body and cause *generalised infection,* which is known by various names according to the nature of the lesion so produced.

LOCALISED SUPPURATIONS

A **boil** or **furuncle** results from infection in a hair follicle usually from the skin surface; occasionally resolution may take place without actual suppuration occurring, and the resulting red, tender, rounded swelling is known as a "*blind boil*"; but should suppuration occur, the pus "points" along the line of least resistance, spreading to the surface, and the swelling assumes a conical shape, the apex of the cone showing white or yellow from the thinness of the cuticle over the underlying pus, which later discharges. Frequently a hair can be seen protruding from the centre of the area, and the whole follicle is discharged as a grey necrotic mass, " the core," when it has separated from the surrounding tissue, after which healing rapidly occurs.

The *treatment* consists in protecting the follicles in the surrounding skin, which may best be achieved by choking them with some antiseptic ointment (Ung. hydrargyri is excellent for this purpose), after which the boil should be incised and the pus with the central core evacuated, the wound being dressed with sterile gauze, which should be changed twice daily. Blind boils may be treated by Bier's hyperæmia, but a small incision often eases pain and assists resolution by relieving tension and so increasing the circulation.

Where several boils exist, or where successive crops occur, vaccine treatment may be tried with advantage. Other methods giving good results are the injection of collosal tin (stanoxyl) or manganese, 1 c.c. daily for ten doses, or the administration by mouth of a drachm of fresh brewer's yeast in warm milk twice daily, both of which remedies produce marked leucocytosis. At the same time the fat intake should be increased, butter especially being eaten, and a glass of stout should be taken once or twice daily.

An **abscess**, as has already been pointed out (Chapter III., p. 26), results from the localisation of suppuration in any of the body tissues deep from the surface. Infection may occur from without (exogenous) or by the blood or lymph stream (autogenous), in which latter case the abscess usually occurs in the lymph nodes.

Lymphatic Drainage Areas. It is here not amiss to draw attention to the lymphatic drainage areas of the various regions of the body on which bacteria may impinge, as it is common for organisms to enter by some small abrasion, which may escape notice or only show slight local inflammatory signs, and to be conveyed by the lymphatics to the nearest group of lymph nodes, there to set up extensive suppuration. In this case it must be remembered that both primary and secondary (glandular) seats of infection need treatment.

The lymphatics from the periphery always run along with the veins and drain through the various groups of lymph nodes *en route;* it is, therefore, in the first group of such nodes met with in the course of the vessels from the periphery that infection and suppuration are most likely to occur; but it must not be forgotten that the organisms from these first nodes again may get into the lymphatics and pass to the next group and there cause suppuration, even though the infection has been overcome at both the seat of invasion and in the primary lymph nodes.

It should be noted further that the organisms constitute minute emboli and are so small as only to be caught up in the ultimate narrowings of the lymphatics in the centre of the nodes; hence the infection commences in the interior of the lymph node, which in the early stages can be felt to be enlarged and tender. Later the pus breaks through the gland capsule, with a consequent temporary amelioration of the pain due to relief of tension, and subsequent infection of the surrounding tissues and lymph nodes, which latter are then surrounded by infection (periadenitis) before the gland substance is actually invaded; and indeed in mild cases the invasion may never occur.

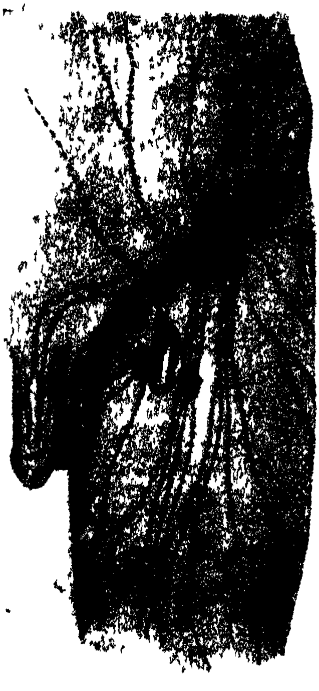


FIG. 22. Superficial lymphatics of the groin.

The lymphatics from the lower extremity drain up along the internal saphena vein to the superficial femoral lymph nodes; those from the outer side of the foot and back and outer side of the leg drain along the external saphena vein, and some enter the popliteal space with its main branch, pass through the popliteal nodes, and so into the deep femoral lymphatics and into the deep femoral group of nodes in the groin; other vessels pass with the venous radicle from the external saphena to the internal saphena collateral and so direct into the superficial femoral group.

The lymphatics from the external genitalia, perineum, anus and suprapubic region pass into the internal or pubic group of nodes in the groin; while those from the abdominal wall below the umbilicus, the back and flank below the angle of the scapula, and from the gluteal region enter the external or iliac group of nodes.

All these groups drain through the saphenous opening and crural canal (where there may be one or two small nodes) into the iliac group, and thence to the aortic group of glands and so into the receptaculum chyli and thoracic duct.

In the upper extremity the lymphatics from the inner aspect of the hand, forearm and arm drain along the ulnar and median basilic veins through the lymph node just above the internal humeral epicondyle, and often through a node situated about half-way up the basilic vein into the group of nodes along the axillary vessels, and thence into the deep cervical glands at the root of the neck. The lymphatics from the outer side of the limb pass with the radial and basilic veins, and usually enter the infra-clavicular nodes situated just beneath the costo-coracoid membrane and deep to the pectoralis major, whence they pass to the axillary and deep cervical glands; occasionally, however, the cephalic vein and lymphatics pass directly over the clavicle and the latter enter the supra-clavicular nodes direct.

The lymphatic vessels from the chest, breast, and abdominal wall above the umbilicus drain into the pectoral group of nodes lying along the long thoracic vessels, and thence into the axillary group, and so to the deep cervical nodes. Those from the shoulder and back above the lower scapular angle drain into the subscapular nodes and thence into the axillary ones.

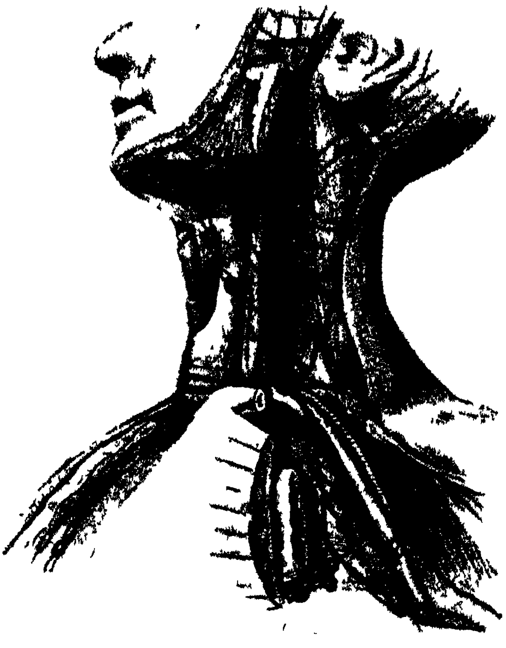


FIG. 23. Deep lymphatics of the head, neck and axilla.

The skin of the arm-pit drains into the small central axillary group (Leaf) and thence to the axillary group on the vessels.

It should be noted that here, as elsewhere, a *very free anastomosis occurs across the midline of the body*, so that a lesion of one side may result in lymph node infection occurring in both axillæ.

From the deep cervical group the lymphatics pass on the left side into the thoracic duct direct, and on the right side into the right lymphatic duct.

The lymphatic drainage of the scalp also follows the venous system, as elsewhere. Thus the forehead, face and lips drain along the facial vein to the deep cervical group of nodes on the internal jugular vein; the ear and temporal region may drain along the anterior temporo-maxillary vein to the deep cervical, or along the posterior temporo-maxillary and auricular veins to the superficial cervical nodes on the external jugular vein.

The chin and lower lip drain into the submental nodes and thence either along the anterior jugulars to the supra-sternal nodes, or back into the submaxillary group.

The lymphatics of the occipital region of the scalp drain in a somewhat complicated manner, following the distribution of the sub-occipital venous plexus, as follows: one group drains down the posterior jugular vein to the superficial cervical nodes, a second along the vertebral vein to the lower deep cervical glands, and a third *via* the princeps and ascending cervical vessels, between the neck of the first rib and the transverse process of the last cervical vertebra directly into the superior mediastinum.

This last group is of particular import to the surgeon, for mediastinitis is a serious and usually fatal complication, and one which is associated not uncommonly with an infective focus on the back of the head.

The lymphatics of the upper lip and malar prominence may drain back along the transverse facial vessels to the preauricular nodes.

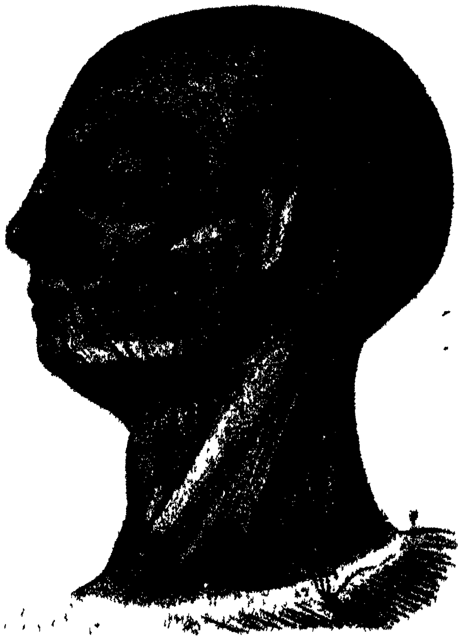


FIG. 24. Superficial lymphatics of the head and neck.

Briefly recapitulating, the various groups of lymph nodes and their cutaneous drainage are as follows:

Inguinal Group of Nodes:	*Cutaneous drainage from:*
1. *Vertical* (*a*) Superficial	Lower limb.
(*b*) Deep	Outer side of the foot and leg.
2. *Oblique* (*a*) Internal (pubic)	Pudenda, perineum and anus.
(*b*) External (iliac)	Buttock, lower abdomen, flank and back (lower).

These then drain to the iliac and aortic retro-peritoneal glands.

Axillary Group of Nodes:	
1. *Axillary* (along the main vessels)	Inner side of the limb and hand.
2. *Pectoral* (along the long thoracic vessels)	Chest, breast, and upper abdomen.
3. *Subscapular* (along the long subscapular vessels).	Back (upper) and scapular region.
4. *Infra-clavicular* (costo-coracoid)	Outer side of the limb.
5. *Central group*	Skin of arm-pit.

Cervical Group :

1. *Deep cervical* (internal jugular)	Face, forehead, lips (and tongue), ear.
2. *Superficial cervical* (external jugular)	Temporal regions, occipital regions, mastoid.
3. *Glandulæ concatinatæ* (posterior triangle)	Occipital region.
4. *Submental*	Chin.
5. *Preauricular*	Upper lip and cheek, malar prominence.

It should be remembered that odd masses of lymphatic tissue may, and frequently will, enlarge in order to resist particular infections, and hence undescribed groups of nodes come into being for a time.

It is a noteworthy fact that although infection usually travels along the lymph vessels, yet actual inflammation of the vessels themselves is uncommon; it does occur, however, and in that case the inflamed lymphatics appear under the skin as a series of red lines, which are tender to the touch. The condition is known as **lymphangitis**, and is frequently associated with severe constitutional disturbance. The treatment consists in efficient drainage of the focus of infection, and hot baths and foments to the affected area, together with rest. The bowels should be opened and the patient be given a light but stimulating diet. In the rare event of pus forming in the lymph vessels, adequate incisions and drainage are indicated (see p. 309).

An **acute abscess** may occur at the original site of infection of the body (primary abscess) or at some distant point (secondary abscess); in this latter case it is situated usually in the adjacent lymph nodes, and, as has been pointed out, its treatment must be combined with that of the original focus of infection, which will have to be sought for carefully in the superficial tissues of the lymphatic drainage area of the affected group of glands. Primary abscess may occur in connection with the intestine (appendix abscess), and secondary ones are met with from blood-stream infections, as in acute osteitis.

The ætiology of acute abscess has been discussed already (Chapter III., p. 26), and also its signs and treatment, but in view of the frequency and importance of this lesion in surgery, it will be well to recapitulate briefly the main points, as the early diagnosis and adequate treatment of suppuration in the tissues is one of the most urgent (and by no means one of the most easy) problems met with in practice.

An abscess is always due to bacterial infection which has become localised by the inflammatory reaction of the surrounding tissues, the pus formed by the dead tissue and organisms being shut in by a wall of leucocytes and tending to " point " along the line of least resistance as its tension increases.

It must never be forgotten that it is upon the integrity of the leucocytic barrier that the localisation of the infection depends, and therefore any violent manœuvre, such as scraping or squeezing, which breaks down this barrier without providing free exit for the pus to the exterior, cannot be too strongly condemned as almost certain to convert the abscess into a cellulitic, or even a general, infection.

Locally all the signs of inflammation, *pain* (which will be of a throbbing character owing to the tension of the pus causing the pulse to be appreciated in the area), *heat*, *swelling* (œdematous in character) and *redness*, will be present, although the two latter signs may not be apparent if the suppuration is situated deep to a dense fascial plane, such as the parotid fascia. *Fluctuation* also will be detected. There will be a varying amount of constitutional disturbance, which will vary directly with the tension of the pus in the abscess and consequent toxic absorption, and a "hectic" temperature.

The *treatment* consists in the immediate evacuation of the pus by a free incision at the most dependent part of the abscess cavity. Should the abscess be deeply situated, an adequate incision may be contra-indicated, for the reason that it would damage important structures; in which case drainage must be insured by the insertion of a rubber tube, which should be left in position for about forty-eight hours, and should be rotated daily if it is in contact with vessels or the intestine, in order to prevent ulceration of these structures, with subsequent secondary hæmorrhage or fæcal fistula.

Gauze plugging, which acts by capillary attraction, is often advocated, but is not nearly so satisfactory; if it is used it should be very lightly laid in, and not rammed home with a probe, in which case it corks up the incision and retards the outflow of pus.

Probably the best dressing to use is frequently-changed sterile dry gauze, but this is not always obtainable in practice, when a dressing of 1 in 80 carbolic or flavein may be substituted advantageously. Hot, moist dressings and *fomentations should be avoided,* as they tend to make the surrounding skin sodden, and so lead to infection of the hair follicles in the neighbourhood.

Hot baths may be used between dressings, or Klapp's suction bell applied, *but on no account should the pus be "squeezed" out;* if the abscess is not draining, enlarge the incision.

Ulcers. If infection occurs on the surface of the body, then the resulting inflammation and toxic action of the infecting agent will result in a localised death of the epithelium, and sometimes of the subepithelial tissues, which will be exposed to view, covered with dead cells and pus, these later disappearing and being replaced by granulation tissue. Such a lesion is known as an **ulcer,** and the dead tissue present in the early stages in some cases is called a **slough.**

Ulceration therefore may be defined as *cellular (molecular) death of epithelial tissues following infection.*

If left alone the granulation tissue on the floor of the ulcerated area exudes a serum which, mixing with the organisms, becomes turbid, forming a thin sero-purulent and irritating exudate (*ichorous discharge*), which runs from the raw surface and coagulates over it, forming a *scab.* Under this scab, when the tissues have overcome the infection, healing occurs, and the epithelium having grown in from the edges, the scab is loosened and falls off, leaving a clean pink epithelialised scar; this later turns white as the subjacent granulation-tissue capillaries get obliterated by fibrous tissue. This process is known as *healing under a scab.*

In describing an ulcer there are three terms in common use, which it is well to understand before proceeding.

1. *The floor of an ulcer* is the area denuded of epithelium which can be seen on inspecting the lesion. In the early stages it may be covered by a slough of dead cells, and later by pus or sero-pus, but when the ulcer is clean and healing it can be seen to consist of bright red granulation tissue.

2. *The edge of an ulcer* is the skin edge at the periphery of the floor; its general outline should be noted, as it indicates the *shape of the ulcer,* and also whether it shows signs of *healing, i.e.,* when it looks blue as the single layer of cells grows in over the red granulations; or of *spreading,* when the skin is red and the edge irregular and œdematous. Further, the condition of the

edge, as to whether it is raised, everted, steep and clean cut or undermined, should be noted.

3. *The base of an ulcer* is the tissue on which the ulcer is situated. This always should be carefully examined as to the presence of inflammatory exudate (œdema), induration indicating fibrosis, fixation to deeper structures, etc.

The *signs of an acute ulcer* are a raw red area denuded of epithelium, frequently covered by a small slough and exuding sero-pus, the whole situated in the centre of a patch of red and œdematous skin. The *pain* present is usually of a smarting nature; *neighbouring lymph nodes* are *enlarged* and *tender*, and may show signs of suppuration, while there is a varying amount of general constitutional disturbance. In the later stages the ulcer's floor may be covered by a scab, the removal of which causes some oozing from the underlying granulations.

Treatment consists in rest to the affected part, which should be dressed with an antiseptic such as carbolic lotion (1 in 80), or perchloride of mercury, 1 in 1,000 (Lotio Nigra), until clean, and then epithelialisation assisted by an astringent dressing such as Lotio Zinci Sulphatis, or a lotion consisting of—

Zinc sulphate	grs. x
Alumen purif.	grs. xx
Glycerin	℥vii
Aqua	ad O i

which has the advantage of not allowing the dressing to adhere to the wound and drag away the newly-formed epithelium.

When sloughs are present, these may be cleaned away advantageously by the use of warm chlorinated soda lotion or eusol dressings; these must be discontinued so soon as the sloughs have separated, as the chlorine destroys growing epithelial cells and so prevents healing of the ulcer.

When an ulcer is perfectly clean, if a minimal amount of the ordinary atropine ointmentis spread on its growing epithelial edge, rapid epithelial growth will occur.

(The ætiology of ulcers and their differential diagnosis are discussed in Chapter VII., p. 143.)

Cellulitis is an inflammatory condition affecting the soft parts of an area invaded by bacteria, the toxins of which have not been localised to the lymphatics by the tissue reaction. The changes are most noticeable in the lax cellular tissues, which become much swollen and œdematous as the result of the presence of the inflammatory exudate, but it must be remembered that other soft tissues, such as the muscles, tendons and nerves, will be to a greater or less extent affected (Chapters XII. and XIII.). Moreover, small effusions into neighbouring joints from irritation of the synovial membrane are of common occurrence, but do not necessarily indicate that the joint is infected (Chapter XIX.).

The *local signs* of inflammation are all present. The *area is brawny, swollen, red and painful;* there is œdema of the subcutaneous tissues, the skin over which is tense, red and shiny in appearance, and may show small blisters, or even areas of necrosis in severe cases, when patches of skin appear black and insensitive. There is severe pain of an aching character due to pressure on the nerve endings and small nerves by the *sero-purulent effusion*, which lies in and around the tissue cells in a varying amount. The edges of the area are indefinite and fade into the surrounding healthy tissue. The affected part is kept at rest, usually in an elevated position, in order to avoid the pain which results from use or congestion. The neighbouring lymph nodes are enlarged and tender and may suppurate.

The *general signs* are much more severe than in the case of a localised abscess; there is marked malaise and anorexia, the tongue is furred, constipation is usually present, and the urine is scanty and high coloured. The temperature is raised and may reach 103° to 105° F., and there may be delirium, especially at night. In children, and even in adults in severe cases, there may be rigors or vomiting.

Treatment, if the cellulitis is localised and no general toxæmia exists, consists in immediate rest and if necessary free incisions into the area in order to give exit to the sero-purulent exudate and relieve tension on the vessels (which enables the circulation to re-establish itself and aids resolution), the tendons (which, being avascular, are very liable to slough), and the nerves (which relieves pain). Here, again, it is essential that incisions be made parallel to the important structures of the region, and in what will be the most dependent position as the patient is lying at rest.

Where generalised toxæmia is marked and the inflammation is spreading, immersion of the area in hot antiseptic baths at four-hourly intervals and dressing with dry sterile gauze between the baths is the ideal treatment in such cases, and also after operation; but should this not be possible, then frequently changed hot fomentations make a satisfactory dressing in the early stages, and can be replaced by gauze soaked in weak antiseptics so soon as the acute inflammation has subsided.

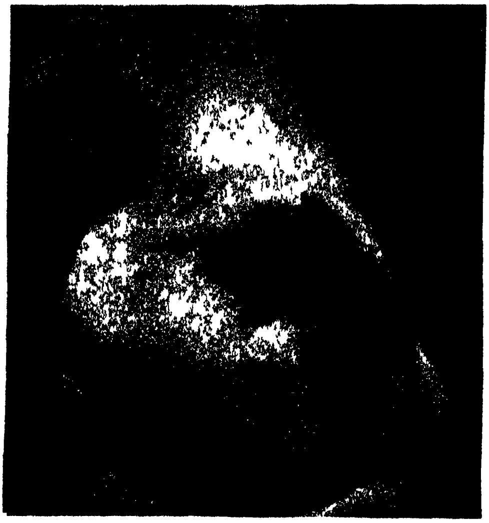


FIG. 25. Erysipelas of breast from infection *via* a cracked nipple.

Where the causative organism is a streptococcus, as is often the case, sulphanilamide drugs should be given by mouth and produce a great improvement in the general condition though little effect locally. Prontosil gm. 7 (2 tablets) should be given twice a day until the temperature has been normal for twenty-four hours.

Attention should be directed to the state of the bowels, which must be opened daily; the diet should be light and stimulating, alcohol in the form of port wine or brandy being of great value in these cases.

Pain and delirium are usually relieved quickly by incisions, but should they persist, Pulv. Ipecacuanha Co., grs. x, or nepenthe, ♏x in wâter, given at night, will be found very efficacious.

Erysipelas (St. Anthony's Fire) is a diffuse infection of the lymphatics of the cuticle by streptococci, and is in every way analogous to cellulitis, though much more superficial. Infection may occur through a wound, but usually follows some small and frequently unnoticed skin abrasion; it is, therefore, more commonly met with on the "bare" areas of the body: the face, neck, forearms and hands. In the days when the importance of asepsis and avoidance of overcrowding in hospitals were not recognised, erysipelas was a very common and often fatal epidemic disease in surgical wards, and thus acquired an importance in the eyes of the medical and nursing professions which it no longer merits. It is peculiarly common in chronic renal disease, and is then often fatal.

The physical signs consist in a local area of skin, which may or may not show an abraded surface, becoming suddenly *red* and *shiny* with a *raised edge;* this erythema *spreads rapidly* and is accompanied by a feeling of discomfort which may amount to a smarting sensation, and blebs containing serum or sero-pus may be seen on the surface of the affected area. *The edge of the area is markedly irregular in outline,* often showing isolated islets of inflammation separated from the reddened edge of the main area by an intervening strip of normal skin, and this "West Coast of Scotland" appearance of the spreading margin is pathognomonic of the disease. In areas, such as the eyelids or scrotum, where there is lax subcutaneous connective tissue, considerable œdema may be present, or there may be associated cellulitis from infection of the underlying tissues by the streptococci, a condition often spoken of as **cellulo-cutaneous erysipelas.**

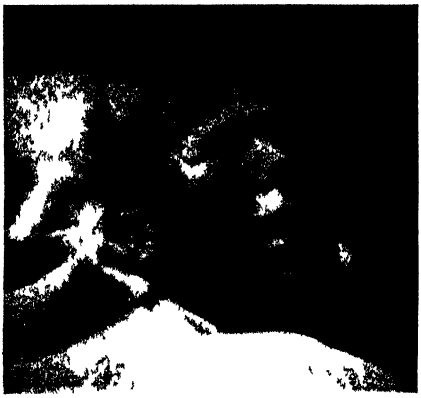


FIG 26 Erysipelas of face.

The general signs vary considerably; they may be negligible, but, on the other hand, are frequently very severe, there being an acute onset with rigors or vomiting and a high temperature, the tongue being furred and brown, the digestion impaired, anorexia, constipation and vomiting often accompanying this symptom, while the pulse is rapid and the mental condition one of low delirium. Cardiac failure may occur. It must not be forgotten that the mucous membrane of the mouth and fauces also may be infected, and occasionally œdema of the glottis will supervene, which, if it occurs, will in all probability necessitate tracheotomy to relieve the respiratory distress.

The condition is very liable to relapse and may do so repeatedly in debilitated subjects; in these cases serum (antistreptococcal) is of value, as also change of air and sunlight or ultra-violet rays. Relapses seldom occur in cases treated by prontosil and this drug should be used at once if a relapse takes place.

Treatment consists in confining the patient to bed and giving stimulants, of which alcohol is the most valuable, and a nourishing diet. The bowels should be opened freely and diaphoresis induced. Dick serum (25–50 c.c.) should be given intramuscularly in cases where there is general toxæmia, and may be repeated in two days' time if this has not subsided. Sulphanilamides (prontosil gm. 7) should be given thrice daily when a great improvement in the general condition is observed within forty-eight hours, but little or no effect is to be seen in the rash; the drug should be stopped when the temperature has been normal for two days. Relapses seldom occur in cases treated with sulphanilamide.

Many forms of local treatment are advocated and practised, but as a general rule are unavailing in checking the spread of the disease.

The application of strong iodine, pure carbolic, or even scarification of the skin beyond the infected area, with the object of promoting an inflammatory reaction, which shall be present to deal with the infecting streptococci when they arrive in the cuticular lymphatics, is of very doubtful value ; as also is the application of strong antiseptic ointments containing ichthyol, carbolic or brilliant green, or of hypertonic solutions of such substances as magnesium sulphate, though this latter, acting by osmosis, will reduce the œdema in areas where it occurs. Probably the best dressing is a moist one of sterile gauze soaked in cold and frequently renewed dilute lead lotion or hypertonic saline.

Abscesses sometimes form in the course of the lymphatics or in the glands above the lesion, and will then require opening.

There are, in conclusion, two points to be noted in regard to erysipelas :—

1. All cases should be dressed with rubber gloves, and, of course, should be done last of all dressings ; particular care must be taken not to convey infection to any parturient woman.

2. Erysipelas is a notifiable infectious disease ; therefore the duty of every practitioner meeting with a case is to notify it at once to the Medical Officer of Health for the district.

GENERAL INFECTIONS

General infection of the body results from the entry into and circulation in the blood stream of the invading organisms or their toxins, and is popularly known as "*blood poisoning.*" From the professional point of view, however, these infections fall into three well-defined classes, known as :—

1. *Sapræmia or toxæmia,* a term applied to cases where the organisms remain localised at the site of infection and their toxins alone enter the circulation, examples being tetanus and certain cases of puerperal infection.

2. *Septicæmia,* where the actual organisms themselves are found in the blood and tissues distant from the original seat of infection and are multiplying there.

3. *Pyæmia,* where the organisms circulating in the blood stream become held up in distant parts, usually in the capillary plexuses, being considered by some authorities to be conveyed in clumps in fragments of disintegrated blood clot. They lodge specially in the lungs and liver, and give rise to suppuration in these situations (pyæmic abscess).

The physical signs of these three conditions vary somewhat, but it is frequently only with the help of the bacteriologist and a blood culture that a definite diagnosis can be made between them.

(A) **Toxæmia or sapræmia,** formerly known as "septic traumatic fever," is due to the absorption of the toxins generated by the bacteria localised in some infected focus, as the post-partum uterine cavity or a septic wound. It may occur in a marked degree as a result of quite a small primary focus if this is under tension, and is the cause of the general signs in erysipelas and other infective conditions, such as general peritonitis and septic osteitis ; in all of these it is often associated with a septicæmia, from which clinically it cannot be distinguished in many cases.

(B) In **septicæmia** organisms as well as toxins are present in the blood, and are multiplying there, but it must be remembered that even when so large a quantity as 10 c.c. of blood is taken for cultural purposes it is often necessary to take two or three cultures before obtaining a positive result. The onset may be very rapid after some slight wound, such as a prick with a needle at a post-mortem examination, and even when the primary focus of infection is discoverable little or no improvement follows its extirpation or cleansing, as is the case in toxæmia.

The local signs of both the above conditions vary with the nature of the wound; if large, it is usually obviously infected, and in any case is red and very tender. Lymphangitis and lymphadenitis in the neighbourhood are usual. Pain may be so intense as to produce vomiting in the very early stages of septicæmic cases. Many of the very worst cases show no local reaction in the wound at all.

The *general signs* consist in *high fever*, often ushered in by a rigor or vomiting. This fever may reach 104° to 105° F. and usually remains high, though slight remissions may occur; in a few cases, where the body reaction to the infection is small or absent, the temperature may be low or even subnormal, a sign of the very gravest significance. The *pulse* is rapid, weak and irregular; the *heart muscle* is affected and hæmic murmurs often present. The *skin* is dry and hot and may show diffuse erythematous rashes much like those seen in scarlet fever, which are also followed by desquamation; *constipation* is usually present, but in bad cases offensive *septic diarrhœa* supervenes. The *urine* is scanty and highly coloured, and blood and albumen are often present, due to infection of the renal epithelium. The patient is usually delirious.

Examination of the blood shows a leucocytosis except in bad cases, where a leucopenia may occur. In severe cases erythematous or even purpuric rashes (from hæmolysis) may occur, the former closely resembling that of scarlet fever, and are of grave prognosis. In septicæmia a blood culture is frequently positive.

The *prognosis* is very grave, especially in septicæmic cases; very little hope can be given in cases where a low temperature exists with a rapid pulse and the blood count shows no increase in the leucocytes. The formation of one or more abscesses in septicæmia is a good sign. The worst forms of septicæmia are usually due to streptococci, and especially to hæmolytic streptococci, but these have to some extent lost their terror since the introduction of sulphanilamide therapy (p. 76).

The *treatment* consists in placing the patient in bed and *freely incising* and *cleaning*, or even extirpating, the primary focus of infection, which should then be regularly dressed with antiseptics and drained. Stimulants should be given freely, alcohol being especially valuable.

Serum therapy may give good results if the causative organism has been identified, and, as prompt treatment is essential, stock preparations must be used. Antistreptococcus serum should be given when this organism is present, the antiscarlet fever (Dick) serum being by far the best.

Bleeding and the infusion of 2 or 3 pints of normal saline solution in order to dilute toxins gives good results in some cases, or the saline may be administered by the rectum or subcutaneously while the patient is kept in an electric hot-air bath to induce diaphoresis; while immunisation-transfusion may be practised, but does not generally give good results.

Chemotherapy has recently had a great revival by the discovery of the antitoxic properties of the *sulphanilamide* group of drugs which exert a beneficial action in all streptococcal infections, including hæmolytic ones, and those due to gonococci, pneumococci, meningococci, *B. coli*, etc., but unfortunately have very little effect in staphylococcal infections. This action has no effect on the micro-organisms themselves, but apparently increases the capacity of the leucocytes to deal with their toxins, and so we see a great improvement in the patient's general condition with loss of toxæmia and fall of pulse and temperature without improvement in the local lesion, where active organisms are still present in great numbers. These sulphanilamides (of which the best known are Prontosil and M. and B. 693) must be given cautiously therefore, as pus may be spreading locally or a highly infective discharge be present in an apparently well patient with a normal temperature and pulse ; moreover, there is in some cases destruction of red cells or white cells with resulting leucopenia and these must be looked for in all cases and if present the drug stopped at once. Cyanosis in a mild form always results and nausea (which is less if the drug is given before meals) but hæmoglobinuria or anæmia, or leucopenia are obvious danger signs. Different sulphanilamide drugs give better results in certain diseases, thus *Prontosil* gm. 7 by the mouth is excellent in all streptococcal infections, while M. and B. 693 in similar doses gives better results in gonorrhœa and pneumonia and *B. coli* infections. Sulphur-containing foods such as eggs, and sulphate salines must be avoided. In *Penicillin* a potent substance has been found to combat the dangers of the majority of coccal infections; unfortunately its effects are uncertain with the pneumo-coccus and absent with the B. coli-typhosus organisms.

The *intravenous injection of antiseptics* has been tried, and sometimes gives very startling and successful results. Eusol, a 0·5 per cent. solution of hypochlorous acid, or perchloride of mercury, gr. $\frac{1}{16}$, may be used, and should be injected daily till the temperature is normal or diarrhœa with colic supervenes.

Septic pneumonia, secondary abscesses, septic arthritis, empyema, etc., may complicate the disease, and should be treated as they occur.

A form of **chronic septicæmia** is also recognised, where the condition is due to the constant absorption of small doses of toxins and organisms from some focus of infection more or less tolerated in the tissues, such as infected tonsils, an hepatic abscess, a chronically infected gall-bladder or appendix, or pyorrhœa alveolaris.

The *signs* are a gradual deterioration of health with a characteristic pallid, "earthy" complexion and some degree of anæmia ; local degenerative changes in distant tissues, such as the joints, are also not infrequent.

The *treatment* consists in removal of the focus of infection, when this can be identified, which is by no means easy ; otherwise vaccine or serum therapy may be resorted to, but is frequently not very satisfactory. Improvement of the general health by a long change and good hygienic surroundings should be aimed at, and much benefit may be thus obtained.

(C) **Pyæmia** differs from septicæmia in that definite abscesses are formed by the organisms in the tissues. The *primary focus* consists not infrequently in an area of infected blood clot in a vein, *infective thrombophlebitis*, portions of which break off and are carried to distant parts as *infective emboli* (see p. 262), forming a nidus for the development of a fresh area of suppuration ; this rapidly extends in the necrosed tissue of the infarcted area beyond the point where the embolus is arrested in the vein.

Such suppurative phlebitis may occur as a result of trauma and infection in varicose veins, but more commonly is a complication of some infective process, as occurs in lateral sinus thrombosis, phlegmasia alba dolens (the white leg consequent upon pelvic infection after parturition), while it may be the sequel of acute osteitis or acute appendicitis; in the latter case the secondary abscesses occur in the liver, a condition which may be secondary to any infective focus in the portal area, and is known as *suppurative pylephlebitis* (see Vol. II., Chapter XVIII.).

The *local signs* will depend on the nature of the primary infection, but the thrombosed vein often can be felt as a hard, tender cord.

The *general signs* consist of a series of rigors, accompanied by a hectic temperature, and often succeeded by the appearance of the secondary abscesses.

These abscesses most often occur *in the lungs*, the periphery of the lobes in their lower and back parts being the favourite seat; they are usually small in size and cannot be detected unless in large numbers, when the infarcted area will give a dull note and diminished breath sounds. When disseminated throughout the lungs they give rise to signs analogous with those of diffuse bronchopneumonia. *Joints* should be watched carefully, as they are a favourite seat of purulent effusions, which may also occur in the *bursæ* or any of the *serous cavities*; occasionally *brain abscesses* can be detected. They are in all cases painless, and give rise to very little local inflammatory reaction, but their formation is almost always preceded by a rigor. Red and painful subcutaneous nodules may occur, which usually resolve if left alone; these are very common after influenza.

There are the usual signs accompanying toxæmia, as described previously, and in addition acetone is not infrequently present in the breath, where it can be detected by its mawkish hay-like odour.

Treatment consists in the first place in arresting as far as possible the escape of infected clot into the circulation, and this is best effected by ligature of the affected vein between the infected area and the heart; this is practicable in the case of large veins and should be performed clear of the infected area, *i.e.*, at the internal jugular in the neck for lateral sinus thrombosis in mastoid antrum suppuration.

Where the thrombophlebitis is secondary to an infective process, this also must be dealt with by eradication or incision and drainage.

The general measures in use in any toxæmia are of value, as described above.

Secondary abscesses, if accessible or causing toxæmia, need attention, and should be treated in the first place by *aspiration*, which may be repeated should the effusion recur. This is usually effective in producing a cure, especially if accompanied by the injection of about a drachm of ether. Should, however, more drastic treatment be necessary, the abscess must be laid open, the thin sero-pus evacuated, the cavity irrigated with warm sterile saline and the wound closed; this treatment prevents the occurrence of secondary infection, and so is superior to drainage.

Chronic pyæmia occurs usually as the result of mild chronic septic osteitis, and may persist for years, the patient feeling a " bit off colour " occasionally, and then in a day or so discovering a painless swelling which proves to contain sero-pus usually sterile, this constituting one form of "cold abscess." Such cases are often most intractable, but where possible the primary focus should be dealt with; vaccine treatment may prove of assistance, and secondary abscesses must be aspirated when detected.

TEMPERATURE IN ITS RELATION TO DISEASE

This is a matter which calls for only a very brief consideration in a text-book of surgery.

It is well to remember that under normal conditions there is a daily variation of the body temperature, which may vary considerably with different individuals, and, again, that under pathological conditions some patients, especially children, show great rises in temperature for a very small constitutional disturbance.

As a general rule, any variation in the body temperature beyond the physiological daily rise of from 0·5° to 1° from the normal 98·4° F. is an indication that there is some toxic or irritative focus causing increased tissue metabolism, and apart from such obvious causes as immersion in hot baths or exposure to very high temperatures or fatigue, it may be concluded that some bacterial infection is present in the body, the action of the toxins from which are giving rise to a general constitutional reaction. In this relation it should be borne in mind that whereas children show a great reaction in temperature very easily, it may require great provocation to produce even a moderate rise of temperature in an old person.

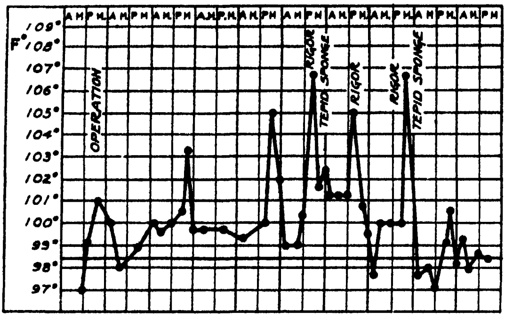


FIG. 27. Temperature in pyæmia following excision of an unlocalised carbuncle.

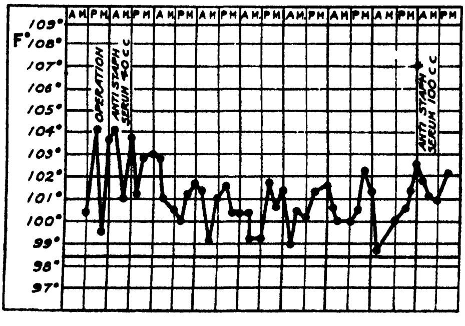


FIG. 28. Temperature in staphylococcal septicæmia with suppurative osteitis.

The temperature of the body under normal conditions varies somewhat in different individuals, and may be as low as 97° F. or as high as 99° F., the so-called normal temperature being 98·4° F. (37° C.). In disease this will be raised and, according to whether it remains persistently above normal or returns at intervals to the normal level, is called remittent or intermittent in type.

Remittent fever is not commonly met with in surgical practice, and is nearly always of grave significance as indicating a generalised infection, as in septicæmia, typhoid, etc.

Intermittent fever, usually with daily intermissions, is met with in a variety of surgical conditions, the temperature being found to be highest at night, and returning to normal or below in the morning.

It is the common type of temperature met with in suppuration, where it may vary from 101° to 105° F. or even higher, and where the maximum temperature is reached between 8 p.m. and midnight.

It is met with in tuberculosis of all types, and, inasmuch as in this disease the maximum rise is noticed between 4 p.m. and 8 p.m., it may be of assistance in diagnosing the condition.

In rapidly growing neoplasms, especially sarcomata, the same temperature is present, but it seldom rises above 100° F., and the maximum is usually at 8 p.m.

In pyæmia and malaria a sharp rise of temperature, often associated with a rigor, denotes liberation of organisms in the blood stream, with infection in distant parts of the body.

A **rigor** is the term applied to a condition due to a sudden acute infection, where the patient at first feels very hot, with a hot, dry skin and flushed face, while the temperature is high and rising and the bedclothes are frequently thrown off; to this succeeds a stage of intense feeling of cold with uncontrollable shivering and then sweating, during which the temperature falls and the patient demands extra clothes and hot bottles. The condition may be met with at the onset of any severe infection, and accompanies the formation of pyæmic abscesses or infarcts, or it may be the result of the liberation into the blood stream of successive broods of malarial parasites.

A **subnormal temperature,** if occurring in conjunction with a rapid pulse, or during an acute infection, is of the gravest significance, signifying as it does the inability of the tissues to react to the infection. A rapid fall of temperature frequently precedes death, though this is by no means universal, and indeed in many acute infections a rapid rise may occur and even continue for a short time after death.

Aseptic traumatic fever, as occurring from the absorption of any large collection of blood, hæmatoma, pelvic hæmatocele, etc., has been discussed on p. 22, Chapter II.

CHAPTER VI

SPECIFIC INFECTIONS

SPECIFIC infections of the body from a surgical standpoint may be conveniently classified as under the following headings:—

I. **Pyogenic.**
  (*a*) *Intestinal Bacteria.* B. coli-typhoid Group. B. dysenteri shiga-flexner—B. proteus—Anaerobes.
  (*b*) *Diplococcal.* Gonorrhœa—Pneumonia—Meningitis.
  (*c*) *Chancroid.*

II. **Non-pyogenic.**
  Tetanus—Rabies—Anthrax—Glanders—Leprosy—Diphtheria

III. **Infective Granulomata.**
  (*a*) Tuberculosis.
  (*b*) Syphilis.
  (*c*) Lymphogranuloma inguinale.
  (*d*) Frambœsia—Yaws.
  (*e*) Delhi boil, etc.
  (*f*) Actinomycosis and allied streptothrices. Madura foot.

IV. **Toxic.**
  Gout—Rheumatism—Rheumatoid and Osteo-arthritis—Zymotic fevers.

V. **Parasitic.**
  Hydatids, Trichinosis, etc.—Bilharziosis—Filariasis—Amœbic Colitis.

As has been already pointed out, the term "specific infection" is somewhat loosely applied either to various lesions which can be shown to be due to a given organism, or to the same group of signs and symptoms for which no organism may be detected but giving an identical clinical picture.

I. PYOGENIC SPECIFIC INFECTIONS

(*a*) *Intestinal bacteria* are always present in the intestinal canal, and while confined within its limits are not harmful, but should they escape into the tissues or the blood stream they are very pathogenic, and may give rise to a variety of signs and symptoms according to the tissues attacked.

B. coli, which is a normal inhabitant, may give rise to boils and abscesses, in which case the pus is usually thin, and always odourless if the B. coli alone is present. In many cases other organisms are present, such as B. proteus, and cause the characteristic fæculent smell in the pus due to intestinal infection.

These abscesses may occur in any situation, but are commonly situate in the loins, abdominal wall or perineum. **Ischio-rectal abscesses** are frequently of this nature, and usually follow infection of a thrombosed pile in the lower rectum; they must be dealt with by early and free incision to prevent the danger of a fistula developing (see Vol. II., Chapter XIX.).

Infection of the urinary passages is not uncommon, giving rise to cystitis and pyelitis and calculus formation with an acid urine (see Vol. II., Chapter XX.).

Infection of the biliary tract causing cholecystitis and gallstones is dealt with in Vol. II., Chapter XVIII.

Occasionally a septicæmia may follow a blood-stream infection, and can be diagnosed from other septicæmias only by blood culture. The prognosis in these cases is grave.

Treatment of all B. coli infections may be prolonged and disappointing, but good results often follow the use of sulphanilamide drugs, mandelic acid, an autogenous vaccine or in some acute cases of a specific serum.

B. proteus is usually present in abscesses with B. coli, and causes a very foul odour. It is not infrequently met with in the urinary tract in elderly men, with chronic cystitis following the obstruction to the urinary outflow due to adenoma of the prostate, and renders the urine peculiarly offensive.

B. pyocyaneus, if present, gives rise to a blue-green pus, and is of grave significance in the prognosis of the case.

Both these organisms may give rise to a septicæmia which is usually rapidly fatal.

Anaerobes may occur in abscesses due to intestinal fauna in the tissues, in which case gas is present, and may cause a tympanitic note over the abscess, with usually acute pain. On incision the gas will escape with a hissing noise, and may be odourless or very foul.

More generalised infections due to anaerobic intestinal organisms are dealt with in Chapter VII., p. 164.

There is a second group of intestinal organisms which are not normally present in the intestinal tract, and which when they occur there give rise to definite pathological lesions. These organisms may escape into the tissues and then give rise to various lesions comparable to those just described, but more serious in that the organisms are actively pathogenic, and therefore require great care in treatment. Moreover, in many cases the host may have become tolerant to the organism, and be unaware that it is still within his body, and yet be capable of infecting others through discharges containing the organism; such individuals are known as "*carriers,*" and are a source of great danger to the community.

B. typhosus is not infrequently found in the gall-bladder (Vol. II.) or in the urinary tract (Vol. II.); more rarely it occurs as a cause of thrombosis of the deeper veins of the pelvis, with consequent compensatory varicosity of the more superficial veins of the lower extremities and abdominal wall (see p. 284), and still more rarely as a source of localised abscesses in the region of the costal or epiphysial cartilages (see p. 543).

In all cases there is usually a history of typhoid fever, but occasionally the attack has been of the mild ambulatory form and has escaped notice.

Treatment should be prompt: in all cases hexamine (urotropine), grs. x t.d.s., in combination with an equal amount of acid sodium phosphate to ensure the liberation of formalin in the tissues, is a specific, while removal of the gall bladder may be necessary. Care must be taken that all discharges are carefully disinfected, and that dressings are burned. Needless to remark, all dressings must be done in rubber gloves.

B. shiga and flexner, the organisms of bacillary dysentery, rarely may give rise to abscess formation in debilitated patients, but they not infrequently cause a severe toxic synovitis affecting many joints and temporarily very crippling (see p. 598).

Treatment consists in the administration of dysenteric serum, and is on the whole satisfactory.

(*b*) *The diplococcal infections* are a common and important group :—

GONORRHŒA

This is an infective condition due to the infection of a mucous membrane, usually that of the urethra or cervix uteri, with the gonococcus (or diplococcus of Neisser), which is undoubtedly able to penetrate and infect the cells in undamaged epithelial membranes. This organism is bun-shaped and usually occurs in pairs, but may be seen in tetrads in the pus. It is frequently intracellular in the leucocytes, and is characteristic in its staining properties, being Gram-negative. Infection also may occur in the mucosa of the rectum, bladder, nasal passages and mouth, or in the conjunctival sac, either as a secondary infection, due to direct transmission of pus, or occasionally as a primary infection. The disease usually follows coitus with an infected person and may manifest itself in from two to twenty days, though usually it occurs on the third or fourth day after infection. Subsequent attacks are not uncommon, though usually not so severe as the primary one, but in this context it must be borne in mind that it is sometimes difficult to differentiate between a new infection and the lighting up of a persistent chronic infection.

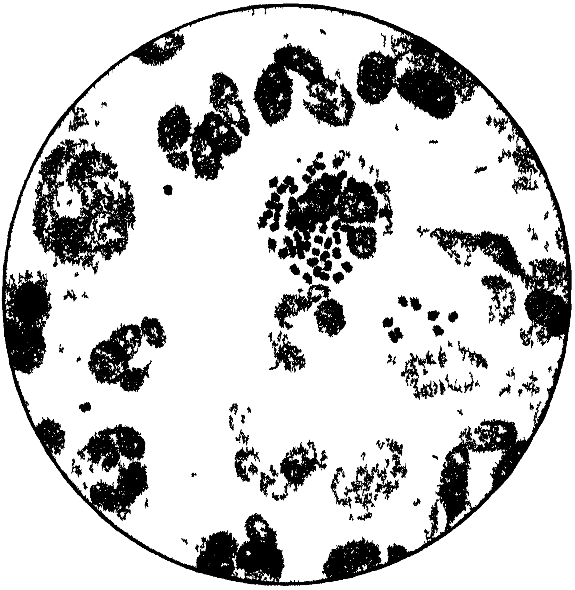


FIG 29 Gonococci in pus (× 1,000).

The *constitutional symptoms* are not usually severe, the patient feels " off colour," there may be dragging pain in the loins and perineum, constipation, with a dirty tongue and slight fever—these usually subside in about a week.

The *local signs* vary somewhat in the male and female patient, and will be described separately with the local complications which are liable to occur, and which render gonorrhœa such a serious and intractable malady.

(A) *In the male* the earliest sign of trouble is usually a smarting in the urethra noticed on micturition, and on examination the meatus is found to be red and swollen, the urethra is usually tender on pressure and a small amount of sero-pus can be squeezed from the meatus. In a day or so the purulent discharge becomes free, yellow and thick, and there is often frequency of micturition and priapism due to local irritation. If the urethral mucosa be examined it is very red and congested, in places desquamating and showing areas of granulation, particularly around the mouths of the mucous glands of Littré. Hæmorrhage is easily caused from these areas, and not infrequently may occur spontaneously. Urinary retention, due partly to congestion and partly to reflex spasm, may be a complication.

This stage usually lasts from a week to ten days; the discharge then becomes white, and so continues for perhaps another fortnight, when it gradually becomes mucoid and glairy, and in an uncomplicated case ceases in from six weeks to two months. This does not mean that the patient is of necessity cured, and in the majority of cases gonococci can be demonstrated in the discharge expressed after manipulating the urethra, or from Littré's glands on urethroscopic examination, quite apart from any complications such as prostatitis or posterior urethritis having occurred.

Treatment in the acute stage consists in keeping the patient quiet, if possible in bed, on a low diet, and avoiding alcohol and sexual excitement of any kind. The bowels should be kept open regularly by some aperient such as Mist. alba; and Mist. Pot. Citrate (gr. xxx) c̄ Hyoscyam. may be given with advantage at this stage. Sulphanilamide (Prontosil, M. & B. 693) should be given (grams 7 t.d.s.) for a week or ten days; some give this at once and others after the first few days of discharge so that a local immunity may be developed. The discharge ceases in a few days, but the patient must not be regarded as cured as relapses are frequent. Smears must be taken following prostatic massage and if the gonococcus is present further courses of treatment must be instituted.

It is essential that the patient be impressed with the fact that the discharge is infectious both to himself and others, and that every care must be taken to avoid contaminating his fingers and then conveying pus elsewhere. Gonorrhœa bags always should be worn to collect discharge, and these must be burnt on removal.

Whether or not local irrigation of the urethra should be carried out in this stage is a controversial subject; many cases clear up well without it. If urethral irrigations are employed—and at the present time they are much used—they should be frequent, and of some mild antiseptic, such as potassium permanganate in 1/8,000 solution, which is in a reservoir held on a level with the patient's head, *i.e.*, about 4 feet above the level of the bladder, and the fluid is then passed back into the posterior urethra and bladder, which are also irrigated. In the later stages the permanganate solution may be twice as strong, and irrigation once daily suffices; then, when the discharge has apparently ceased, urethroscopy, with cauterisation of any follicles seen to be exuding pus or granulating, usually will be satisfactory in cleaning up the infection, but may need repetition in about ten days' time. This is most essential in order to prevent the persistence of a **chronic urethritis** due to the gonococci being harboured in the inflamed urethral glands; this is one of the commonest local complications of gonorrhœa, which is manifested by a slight glairy urethral discharge or *gleet*, most noticeable on rising in the morning, and it may, indeed, give no other signs. Frequently, however, there may be some redness at the meatus and a certain amount of local irritation; gonococci are present in the clear discharge which always can be expressed from the urethra, andit cannot be too strongly impressed on all concerned that the disease always will be transmitted to a woman if sexual intercourse is indulged in at this stage.

Other local complications which may occur during the acute stages or follow the lighting up of a chronic gleet are:—

(1) **Posterior Urethritis,** which leads to frequency of micturition and a heavy sensation in the deep perineum, is a very frequent complication due to the backward extension of the infection beyond the compressor urethræ muscle into the prostatic urethra. So common is it, indeed, that many authorities contend it always occurs, and that routine washing through into the bladder is advisable in all cases of acute gonorrhœa.

(2) **Prostatitis** occurs as a sequel of the direct infection of the prostatic ducts from the posterior urethra and takes two forms:—

(*a*) **Acute.** It is sudden in onset, with great pain and a sense of fulness and discomfort in the perineum, which is acutely tender to the touch, though seldom œdematous, as the inflammation is deep to the triangular fascia. The anal sphincter may be tightly contracted; rectal examination, which is acutely painful, will reveal a hot, swollen and very tender gland. **Prostatic Abscess** often results, and, the pus being pent in by the dense prostatic capsule, gives rise to severe toxæmic symptoms; a high temperature, often complicated by rigors, is present, with vomiting, constipation and a general feeling of severe malaise.

The œdematous gland bulges into the bladder and urethra, which is frequently obliterated, and so retention of urine ensues, which may be relieved either by catheterisation with a silver instrument, or by suprapubic puncture. The condition nearly always terminates in abscess formation, the pus usually being evacuated into the bladder or urethra, often consequent upon instrumentation, these being the line of least resistance, as here the prostatic fascia is far less dense. Incision through the perineum may be necessary in some cases, but the pus should never be evacuated through the rectum, as a secondary infection of the gland nearly always results.

(*b*) **Chronic.** This occurs later in the disease and gives rise to a sensation of weight and discomfort in the perineum; it is a frequent source of "gleet." On rectal examination the prostate can be felt enlarged, slightly tender, and may contain hard nodules in places; massage will express from the ducts long characteristic "threads" of muco-pus, which can be recovered in the urine.

(3) Invasion by way of the *Vas Deferens* may lead to any or all of the following complications:—

(*a*) **Vesiculitis** gives rise to a series of symptoms akin to prostatitis (with which it is frequently associated), only less severe; on rectal examination the seminal vesicles can be felt hot, enlarged and tender, and later fluctuating if suppuration occurs. Pus, if detected with certainty, should be evacuated through the perineum, or across the bladder, rather than left to burst into the rectum.

(*b*) Infection and pus formation occur *in the spermatic cord,* in the lower part of the inguinal canal. There is a painful, red, œdematous swelling in the region of the canal, which may be mistaken, on a superficial examination, for a strangulated inguinal hernia. Treatment consists in evacuation of the pus when it has formed.

(*c*) **Epididymitis and Epididymo-orchitis** are characterised by sudden pain and swelling of the epididymis, which is acutely tender, while œdema of the skin of the scrotum is not uncommon. In the early stages the swelling is confined to the epididymis in the back part of the scrotum, but later the testis becomes somewhat swollen and tender. A small lax hydrocele may be present, but is never enough to mask the outline of the local swelling. The scrotum should be supported in a suspender, and the patient confined to bed while the pain is acute.

All these three may appear as complications of chronic gonorrhœa.

(4) **Cystitis** is, curiously enough, a rare complication of acute gonorrhœa, but does occur, there being intense hypogastric discomfort and some tenderness, with a constant desire to empty the bladder. Treatment consists in the administration of sedatives and regular bladder washes.

(5) **Pyelitis** is another complication of rare occurrence, characterised by pain in the loin of the affected side, the condition seldom being bilateral.

It is important to note two facts in connection with all the above local complications:—

(*a*) Their onset is invariably accompanied by a cessation of the urethral discharge, however free this may be.

(*b*) Suppuration often supervenes, and the infected organ is left permanently damaged, usually disorganised.

Other complications which occur may be briefly referred to and fall into two groups:—

(1) *Contact infections*, the pus being conveyed to other mucous membranes. *Proctitis*, *Conjunctivitis*, *Rhinitis* (Vol. II., Chapters XIX., VI., VII.), etc., may all result, and will be dealt with under the appropriate headings. As has been already stated, these may be prevented by urging on the patient the necessity of very careful washing after handling the infected genitalia, and they are fortunately not so common now, as they result, especially in eye infections, in very serious local damage.

(2) *Blood-stream infections*, which may occur at any stage of the disease, and which in the worst cases may give rise to a rapidly fatal *Septicæmia* or *Pyæmia*, both of which complications are fortunately rare; but in the course of these *endocarditis* (usually of the malignant type) may occur, and is usually fatal. The gonococcus may be implanted in any tissue, but is particularly prone to infect the planes of cellular tissue, more especially in places where these are subjected to strain, as in the regions of the joints, and such places as the sole of the foot and loins; in consequence **Gonorrhœal Fasciitis, with subsequent joint infection,** is one of the commonest complications of the disease. It would be out of place to discuss these complications in detail here (they are fully dealt with in Chapter XIX., p. 596, and also Chapter XX.), but it may be useful to note the following salient points which help to differentiate gonorrhœal from other infections around the joints:—

(*a*) The onset is sudden, very acute and painful, and the condition tends to improve slowly and steadily from its onset, though the infection resolves very slowly. Periarticular thickening and œdema are especially marked.

(*b*) It may be of two distinct types: (i.) *Suppurative*, when often only one area is affected, usually in the region of a large joint; and (ii.) *Non-suppurative* —here often numerous areas, or very large sheets of fascia, are involved, but suppuration rarely supervenes.

(*c*) In either case the infection is followed by great disability and impaired function, there being frequently both false and true ankylosis of the affected joints, with almost complete loss of movement.

(*d*) The disease is therefore a very crippling one, and the prognosis very grave as regards ultimate use of the affected part.

(B) *In women* the acute stages often escape unnoticed, or are put down to the natural result of early marital intercourse; hence the disease has often passed to adjacent organs and caused widespread and too frequently irreparable damage before it is detected. The primary infection is all too commonly from an uncured gleet in the husband, though the disease may perhaps rarely be acquired from an infected closet seat or fouled garments. It is universal among prostitutes of all classes.

Signs. The disease in the early stages is characterised by a slight smarting and itching of the external genitalia, which on examination are found to be red and œdematous, and secrete a thick yellow pus with a peculiar fœtid odour; this may also be squeezed from the urethra. In adults the inflamed vaginal mucosa recovers first, and its normal pale pink walls are in marked contrast to the reddened appearance of the vulva and the cervix uteri, which latter can be seen red and swollen through the speculum, if this be passed. The disease, if untreated, often passes into the chronic stage, and is then likely to be overlooked unless a swab of the slight muco-purulent discharge be examined by smear and culture, or complications supervene.

Treatment consists in baths and irrigation with weak antiseptics, which should be kept in contact with the uterine cervix between whiles by means of adequately inserted plugs. As in the male, aperients, sulphanilamides, and Mist. Pot. Cit. should be given. Sexual intercourse should of course be forbidden. In the later stages silver nitrate, 10 per cent., may be applied direct to the cervix uteri.

The *local complications* in women may be widespread and serious owing to the direct communication between the uterine cavity and the peritoneum—these are fully dealt with in Vol. II., Chapter XXII., and form one of the most trying problems with which the gynæcologist may be faced. To enumerate them briefly: *Endometritis* (infection of the lining membrane of the uterus), *salpingitis* (with its serious troubles from blockage of the lumen of the Fallopian tube, and adhesions to the ovary, with consequent *tubo-ovarian abscess* and *sterility*), *peritonitis* (which is frequently fortunately confined to the pelvis, but may become general and fatal), and such comparatively lesser evils as *cystitis* and *pyelitis* are the chief of the risks to which the woman infected with gonorrhœa is exposed, though of course she is equally liable, with man, to any of the contagious or blood-borne complications already enumerated.

Pneumococcal infections occur usually as septicæmic manifestations during or subsequent to a pulmonary lobar pneumonia, or—and more rarely—to pneumococcal otitis media, but occasionally in young girls a primary pneumococcal peritonitis is met with and is frequently fatal. Empyema of the pleural sac, synovitis and arthritis, peritonitis, and occasionally meningitis, are met with; that is to say that the organism is very prone to attack the serous sacs, where it sets up an acute inflammatory lesion, attended with the formation of a characteristic thin greenish white pus, with a heavy curd-like residuum from which the causative lance-shaped extra-cellular and Gram-positive diplococcus can be recovered in large quantities.

The *diagnosis* is usually easy as the pulmonary lesion coexists, but should any doubt exist, aspiration of greenish pus containing the pneumococcus removes all doubt.

The *prognosis* is very grave, a fatal termination being common.

Treatment consists in opening the affected cavity, removing all pus and the curd-like masses of lymph residuum and closing the wound; subsequent aspiration on one or two occasions may be necessary. M. & B. 693 should be given in all such cases and serum is often useful.

Meningococcal infections are of but little interest to the surgeon, but occasionally the rigid retracted abdomen of the meningeal patient, with referred abdominal pain, may lead to some difficulty in diagnosis in the early stages, where abdominal lesions such as a perforated viscus may be suspected. A careful general examination, however, will reveal other signs of meningitis, head retraction, rashes, Kernig's sign, etc.

(C) **Chancroid** (soft chancre) is also discussed on p. 152, Chapter VII. It may affect both males and females equally, but is more often detected in the former, who are perhaps rather more liable to infection, as the acid vaginal secretion is inhibitory to the growth of Ducrey's bacillus.

The incubation period is short, and usually within forty-eight hours of connection a red papule appears on the genitalia ; this soon becomes vesicular, is a pustule in a day or so, and in four days has broken down and left the characteristic irregular ulcer, which spreads fairly quickly and may cause extensive destruction of the genitalia.

The discharge is very infectious, hence usually three or four ulcers are present, and the neighbouring lymph nodes rapidly become infected and swollen (bubo) and soon break down and suppurate.

Normally the sore is healed in three weeks, and its persistence after that time, especially if associated with induration, is very suspicious of there being a syphilitic infection also present.

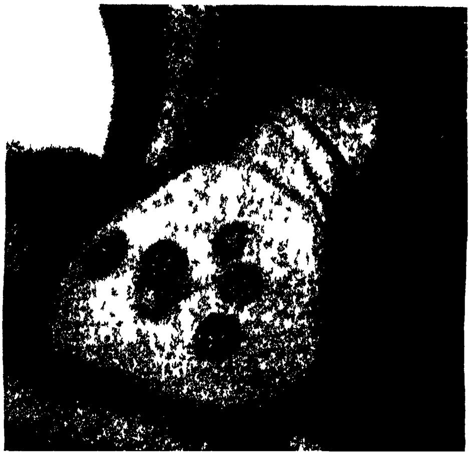


FIG 30 Multiple soft chancres on glans penis.

Treatment consists in keeping the area clean and applying some mercurial salt in solution, for which purpose lotio nigra answers admirably. Some prefer to dust the area with iodoform powder, but this, though an excellent antiseptic, has the disadvantage of possessing a penetrating and characteristic odour. Dmelcos vaccine is the specific remedy ; two to four injections, ½–1 c.c. intravenously, are given every other day, the dosage being regulated according to the severity of the reaction. Sulphanilamide drugs assist healing.

Suppuration in the glands should be dealt with by aspiration, repeated if necessary. This usually results in the local inflammation subsiding, but if an incision is made for drainage, it occasionally becomes infected with Ducrey's bacillus and a typical sore forms in the groin ; this unfortunate complication is often known as a " virulent bubo."

II. NON-SUPPURATIVE BACTERIAL INFECTIONS

(a) TETANUS

This is a sapræmic condition which results from the local infection of a wound with the Bacillus tetani. This organism, which is a strict anaerobe, and capable of forming very resistant endospores, which are situated at one extremity of the rod and so earn it the name of the "drum stick" bacillus, is widely distributed in all soil or dirt which is contaminated with horse dung, and is thus present in all garden soil, especially when well manured, and street dust. The organism is a fine rod-shaped bacillus, with numerous flagellæ, and is very hard to isolate in pure culture, as it is usually associated with pyogenic organisms, in the presence of which it flourishes, for these use up the oxygen in and around the wound, and so provide the anaerobic conditions necessary to the growth of the B. tetani.

It should further be borne in mind that a very small incision or deep punctured wound is similarly very liable to be followed by a rapid growth of the bacillus in its depths. During the last war it was found that the majority of the wounds contaminated with soil from vineyards and cultivated fields became infected with tetanus, which was able to grow rapidly owing to the presence of pyogenic organisms, as has been pointed out already in Chapter IV., p. 42. This condition in the wounds also favoured the growth of the anaerobic intestinal bacteria, also found in the soil, which were the cause of gas gangrene.

Whereas, however, these gas-forming organisms spread into the tissues and blood stream causing a septicæmia, the B. tetani remains strictly localised to the area of the wound, and causes a sapræmia from absorption of its toxins only, and it is further of note that the presence of these toxins in the wound much favours the rapidity of multiplication of the bacilli; indeed without the presence of a small amount of toxin, the B. tetani will usually not develop. In civil practice tetanus usually follows accidental wounds, especially if penetrating in character, such as those resulting from the penetration of a rusty nail into the foot, and above all road accidents.

Mode of Action of the Toxin. The toxin is probably absorbed direct from the blood stream to the motor cells of the central nervous system, though it was thought to travel there by the myelin sheaths of the peripheral nerves; on the motor cells it exerts its action in a manner very like that of strychnine; but with this marked difference—that, whereas the resulting spasms in strychnine poisoning are clonic only and the muscles between the spasms are quite relaxed, those in tetanus are clonic supervening on a persistent tonic spasm of the muscle.

One or two of the proofs that the toxin may travel in the nerve, or in the perineural lymphatics, may be quoted briefly; they consist in the results of experiments which show that the injection of a very small amount of tetanus toxin into a nerve sheath is followed by a much greater spasm than if five or six times the amount of toxin is injected into the muscle, and that the results are the same if the blood and lymph vessels from the area be destroyed, but that complete section of the nerve will prevent or much delay the onset of the spasm. This last phenomenon is of interest, as it explains the benefit which resulted from the now abandoned operations of nerve stretching and neurectomy in cases of tetanus.

The main stress of the infection is found post-mortem in the anterior horn cells in the cord and the cells of the motor cortex cerebri, which usually show marked degenerative changes, whereas the peripheral nerves, along which the toxin has travelled, appear normal, though the injection of an emulsion of such a nerve into an animal will produce tetanus, showing the toxin to be present.

The clinical signs of tetanus are mainly general, as locally the condition of the wound presents no special characteristics though it is usually inflamed; indeed the infected place may be so minute as to escape detection. A smear should be taken from the deeper part of any wound found, as this may reveal the presence of B. tetani. The general signs appear after an incubation period which may vary from two days to over three weeks, according to how long it takes the toxin to travel to the central nervous system, and depending on the virulence of the toxin as to the amount which is necessary to produce the spasms; as a general rule these commence in from ten to eighteen days after infection.

Not infrequently there is tenderness and rigidity in the muscles around the wound, but this is often attributed to the inflamed condition of the latter. The next sign is a stiffness and rigidity of the muscles of the back of the neck; the sterno-mastoids stand out as ribbon-like bands, and the head is held stiffly, with the chin a little elevated; this is co-existent with a spasm of the temporal and masseter muscles and inability to open the jaw freely (*trismus*), together with a generalised spasm of the facial muscles, which gives rise to the typical tight-lipped grin of the tetanic patient (*risus sardonicus*). Later, *dysphagia* from spasm of the œsophago-pharyngeal musculature is not uncommon, and by this stage the jaw is held tightly closed, a condition which gives the disease its popular name of " lockjaw." Generalised rigidity of the body muscles now supervenes, together with some respiratory distress owing to the diaphragm and intercostals being affected, and indeed in the later stages the continued spasm of the respiratory muscles frequently leads to a fatal termination.

Throughout the disease severe clonic spasms supervene on the tonically contracted muscles, and these are frequently excited by any disturbing external influence, such as the slamming of a door, and handling or attempting to feed the patient, who should be shielded therefore as much as possible. During these spasms muscles may contract so violently as to rupture, this accident most often occurring in the rectus abdominis. Owing to the greater power of the erector spinæ and gluteal muscles, the body is usually arched backwards (opisthotonos), the abdominal muscles being contracted and the abdomen retracted and board-like; more rarely the body is bent forward (emphrosthotonos), or sideways (pleurosthotonos).

Throughout there is severe and often agonising pain from the continual muscle cramp, and the temperature is often considerably raised, but the mind remains clear to the last, the patient being acutely sensible of his condition. There is profuse sweating, the urine being scanty and frequently containing a fair amount of albumen.

Certain special forms of tetanus merit description:—

Tetanus neonatorum occurs in new-born children from infection of the umbilical cicatrix, and usually comes on a few days after birth. The spasms are generalised, the child often jaundiced, and the disease rapidly fatal.

Cephalo-tetanus (Tetanus paralyticus) is uncommon, but when it occurs is always associated with wounds of the head and neck, especially if on the forehead. The first sign noted is a paralysis of the facial muscles on the side of the injury, not necessarily those supplied by the seventh cranial nerve only, as squint and diplopia are fairly common from paralysis of the oculomotor and abducent nerves. Marked trismus due to spasm of the masseters and temporals soon develops and there may be very great difficulty in swallowing, attempts at which are followed by violent spasm of the pharyngeal constrictors, thus earning this type of the disease the name of *Tetanus* *hydrophobicus*. The mental condition of these patients is usually one of great excitement, and they may get attacks of acute mania, in which they are liable to inflict damage on themselves and their attendants; occasionally an attack of maniacal frenzy is the first sign of the disease.

Rarely mono- or paraplegic forms are met with.

Tetanus fulminans (acute tetanus) is the name sometimes applied to those cases in which the symptoms develop rapidly within a day or so of the infection. They present no special symptoms, the patient wastes rapidly, and dies in from twenty-four to forty-eight hours.

Splanchnic tetanus, with acute abdominal pain, may occur.

Chronic tetanus is a well-known clinical phenomenon and may occur months after infection of a wound, often when no acute stage has been present. It is not infrequent in patients who have had a small prophylactic dose of antitoxin, especially if the wounded area is for any reason disturbed, as from trauma or by a subsequent operation. It is therefore wise to administer a prophylactic dose of antitetanic serum, 500–1,500 units, before interfering with any old wound, especially if this is known to have been received under circumstances likely to be associated with infection with B. tetani, as acute or even fatal attacks have ensued as a result of neglect of this precaution.

The signs are usually a sensation of stiffness in the muscles around the wound, and in more severe cases of the whole limb, with not infrequently a definite stiff neck and some trismus. The muscles in the affected areas can be felt to be hard and tender, and it is sometimes known for this reason as localised tetanus. Clonic convulsions do not usually supervene, and the condition generally clears up in two or three weeks, but more rapidly if treated by antitoxin.

The *prognosis* is always unfavourable in acute tetanus, and should be guarded even in chronic cases. The length of the incubation period, if known, is a most important guiding factor; speaking broadly, all cases occurring under five days are fatal, from five to ten days 95 per cent. succumb, from ten to fifteen days 75 per cent. die, from fifteen to twenty-one days 35 per cent. to 50 per cent. die, and over twenty-one days the vast majority of cases recover.

The prognosis is always worse in cases where the wound has been inflicted on the bare flesh.

The *diagnosis* may present some difficulties, but the thin-lipped grin combined with the upflung chin of the unfortunate patient, suggesting as it does a contempt for both disease and doctor, should enable the trismus in the early stages to be distinguished easily from that due to dental causes, or inflammation of the temporo-maxillary joint. Similarly the stiff neck can be differentiated from the common " stiff neck " and from *torticollis* due to local inflammatory conditions (see Vol. II., Chapter X.).

In the later stages, when convulsions have manifested themselves, the fact that the muscle spasm remains in the intervals is pathognomonic of tetanus; for in both strychnine poisoning and hydrophobia the muscles relax so soon as the spasm passes—though in both these conditions the mind remains unclouded also—thus distinguishing all three conditions from " convulsions " in children, and spasms in adults due to organic lesions in the central nervous system. " Uræmia," that inimitable impersonator of all diseases, may cause trouble occasionally, but here the urine is not only scanty and full of albumen, but also contains casts, and the mental condition and type of the spasms differ from those met with in tetanus. An estimation of the blood urea will clear up the diagnosis at once. Basal meningitis sometimes will cause difficulty.

Immunisation may be: (1) *Active*, by means of injections of 1 c.c. tetanus toxoid subcutaneously at six weeks interval between the first and second doses and a third dose three weeks later; this gives a high degree of immunity the patient's antitoxin content being one or more units per c.c. of serum and this lasts many years. The toxoid is prepared by treating toxin with weak formalin and incubating at 37° C. for a month, when the antigens are retained but the toxicity lost, so that little or no reaction follows the injection of this toxoid.

(2) *Passive*, by the injection of antitetanic serum in doses of 500 units (International) or 1,000 (British) prophylactically in all cases where contamination of a wound has occurred—such immunity is only transitory and severe reactions often occur, but by its use the mortality, even in cases untreated by toxoid, has been greatly reduced. It will be noted the International unit is twice as strong as the British.

Treatment. The treatment of tetanus can be best summed up in the well-known adage "Prevention is better than cure." In all cases where wounds contaminated by road dirt, manure, or garden soil may occur, proper prophylactic injections of tetanus toxoid should be given. While in all such cases where a wound has occurred prophylactic antitetanic serum must be administered, in this relation especial attention should be drawn to the great liability to tetanic infection in wounds of the foot resulting from the penetration of rusty nails, often from the boot sole. By means of these prophylactic injections, which must be given as soon as possible after the infliction of the wound, the incidence of tetanus amongst the wounded in the last war, which was at one time so high as to threaten to become a scourge in the army, was reduced to practically nil, and in those few cases where the disease developed it was because antitoxin had been either refused or not administered early.

Under ordinary circumstances a dose of 500 units (International) or 1,000 (British) of antitoxic serum should be injected intramuscularly, but if the wound is strongly suspected to be infected 1,500 to 3,000 units (British) should be given. It should be noted that if the serum be warmed to body temperature, by immersing the ampoule in hot water, many of the disagreeable sequelæ, such as joint pains and urticarial rashes, which often appear a week or ten days after injection, can be avoided or much minimised in severity.

Once the disease has manifested itself, energetic and prompt measures must be adopted, the three main principles being: (1) to prevent further absorption of toxin, with serum; (2) to control the spasms and prevent exhaustion or asphyxia; (3) to maintain bodily strength. The patient should be placed in a quiet, darkened room, an anæsthetic administered and the wound, if obvious, freely opened up and packed with hydrogen peroxide 10 vols., or excised completely in order to stop the formation of toxin.

Antitoxic serum must be introduced into the body to stop the action of the toxin already absorbed, an easy task when this is circulating in the blood; but when the toxin has combined with the cells of the central nervous system its effects are difficult to combat and death frequently follows from the spasms in spite of energetic treatment. It must be understood clearly that the antitoxin has no effect on the bacteria themselves, for the destruction of which the action of the phagocytes and antibodies, together with oxidising agents, such as hydrogen peroxide, must be relied upon; hence the necessity for the active treatment of the wound.

The antitoxin should be given in large doses—15,000 to 60,000 units (British)—and this dose should be repeated daily for the next two days, and then again at the end of the week if the patient is alive. In whatever form the antitoxin is given, care must be taken that it is sterile and given under antiseptic precautions, and should the serum be old stock, allowance must be made for deterioration in the proportion indicated on the phial in every case.

The antitoxin should be administered *intrathecally* after the withdrawal by lumbar puncture of a quantity of cerebro-spinal fluid, equal in amount to the bulk of serum to be introduced. (Lumbar puncture is usually performed between the third or fourth lumbar spines, *i.e.*, on a level with the line drawn between the highest points of the iliac crests, by introducing a hollow needle between the spines in a forward and upward direction till it can be felt to push through the posterior common ligament, and enter the sub-arachnoid space, a fact indicated by the sudden loss of resistance to the passage of the needle, and the gushing out of colourless cerebro-spinal fluid (see p. 796). This operation must always be done under anæsthesia in these cases, lest a sudden spasm snap the needle ; the spinal canal may be entered in the lower cervical region, but this is not without risk of damage to the cord.)

Intravenous injection of serum seems to be of benefit in the fulminating tetanus, and can be given in saline in those cases where liquids cannot be swallowed ; otherwise it has nothing to recommend it above *intramuscular injection*, which is easier, and from which the serum is more slowly absorbed and eliminated. The best point for this method is midway between the top of the great trochanter and the iliac crest. These methods may be used in combination, or alternatively, if so desired, but it is not advisable to administer two consecutive intramuscular doses at the same spot. Subcutaneous injections of carbolic 1 in 20, and intrathecal ones of magnesium sulphate, have been used to allay the spasms, but their results are disappointing and their use now generally abandoned in favour of antitoxin. Curarin has been given by continuous intravenous drip, but this must be used cautiously as it is a cumulative paralysant of all muscle, and in some cases has caused death from cardiac failure.

In addition to the above treatment the patient must be quietened by the administration of some narcotic, such as chloral or potassium bromide, or nembutal, which must be given freely ; inasmuch as these require some hours to act, they frequently need supplementing in the first day or so by injections of morphia, which drug may need to be used freely to control the spasms. Attention to the bladder by means of a catheter may be necessary.

Avertin has also been used extensively in doses rather larger than those required in basal anæsthesia. The patient may be kept more or less continuously under it for several days. Pentothal may be similarly employed.

Artificial feeding under anæsthesia has frequently to be resorted to, but it must be remembered that the induction of anæsthesia is invariably accompanied by severe and sometimes fatal respiratory spasm.

Care must be taken to eliminate all sources of external irritation such as draughts, bright lights and noises, the occurrence of which often starts severe clonic spasms.

(*b*) HYDROPHOBIA—RABIES

This distressing disease, which results from the bite of an infected animal, is fortunately only rarely seen as an epidemic disease in this country, although it is endemic on the Continent, and particularly common in the south-east of Europe and Asia Minor and India.

The organism is unknown, but occurs in the saliva of the infected animal and enters the body through an abrasion, so that it may occur following the licking of a chapped hand by an infected dog. The dog is the animal most commonly affected, but the disease infects many other animals, jackals, wolves, pigs, cats, horses, etc., and has been known to follow the peck of a bird.

Infection is most likely to follow a wound on a bare area, and the virus shows a marked tendency to attack the nervous system.

The incubation period varies from twelve hours to fifteen months, the usual time being from three weeks to three months before the disease manifests itself; the onset is usually sudden, following on a few hours' moroseness and malaise.

(*a*) In **mammals** the disease assumes one of two types :—

(1) The *morose*—the animal seeks a dark corner and there sits until disturbed, when it becomes irritable and snappy. The appetite is frequently depraved, the animal eating all kinds of filth and rubbish, but efforts to eat or drink result in violent diaphragmatic spasms and retching, whence the disease derives its name. The mouth is filled with ropy saliva, which the animal makes unavailing efforts to remove; in the case of dogs the bark loses its characteristic ringing note and becomes hoarse and throaty.

(2) The "*maniacal,*" where the animal suddenly rushes about in a frenzy, biting and snapping at everything in its path. This form is fortunately uncommon.

In both types the convulsions increase in frequency and force, and are soon succeeded by paralysis and death.

It cannot be too strongly impressed upon the practitioner and the public that, should an animal be suspected of rabies, and more especially if it has bitten any individual, it should not be killed, but be isolated and observed for further signs of the disease, as the post-mortem changes are mainly negative. In advanced cases examination of the central nervous system reveals acute inflammation and vascular thrombosis in the medulla, with degeneration of the ganglion cells, especially those of the vagus, and the presence (especially in lower animals) of Negri bodies in the cerebral cortex and hippocampus major. These bodies, which consist of a mass of small corpuscles surrounded by a clear area and enclosed in a fine capsule, are thought by some observers to represent a stage in the life-history of a protozoon.

(*b*) In **man** the disease is always of the morose type, and is ushered in by a short period of vague and unreasoning terror, in which the patient is morose and sits in dark corners, with usually some aching and tenderness in the region of the wound, which is usually soundly healed. This is succeeded usually by a "catching of the diaphragm" comparable to that experienced on stepping into a cold bath, and frequently induced by attempts to eat or drink.

The spasms are always clonic, the muscles relaxing to normal between, and this persists throughout the attack. The spasms rapidly spread to all the muscles of deglutition, and later become generalised, being succeeded in acute cases by paralysis, usually first seen in the respiratory muscles, and death.

The mental condition is usually rather clouded, and the patient frequently suffers from delusions, especially towards the end. Rarely the patient becomes violent or even maniacal. The mouth is filled with a copious secretion of viscid saliva, which often runs down the chin. The temperature is raised, and the patient frequently complains of cold. The pulse is rapid and irregular. In the later stages the respiration is catchy and stridulent.

The disease is almost always fatal, death occurring in from a few hours to two or three days, according to the severity of the attack, which varies with the length of the incubation period. Cases occurring more than twelve months after infection usually recover, though they often leave some permanent bulbar palsy.

The *differential diagnosis* usually presents no difficulty, although occasionally one may suspect tetanus (hydrophobicus); but here the tonus which persists between the spasms in tetanus will soon clear up the diagnosis. Diagnosis from mental disorders can be made by the discovery of the wound, and by eliciting the history of its infliction.

Care must be taken to eliminate the possibility of functional imitation of rabies, which may occur through fear in persons bitten, especially in those who have previously seen rabies, in whom all the early stages of terror, delusions, painful wounds and even spasms may be seen; but the ropy saliva and generalised spasm never develop, and the onset is usually within a few hours of the receipt of the bite. The case of the patient who approaches on all fours, emitting sharp barking noises, is not worthy of more attention than the application of strong caustic to the wound and an electric battery.

Treatment. In every case where a person is bitten by a suspected rabid animal prompt measures must be adopted, the venous return from the part must be obstructed, and free bleeding encouraged. If feasible the wound should be excised, or if not the tissues must be destroyed with the actual cautery or fuming nitric acid; weak caustics, as silver nitrate, are useless in such cases.

Pasteur's preventive inoculation, which is based on the knowledge that the injection of an attenuated virus in increasing strength protects from the disease, should be at once resorted to, unless the patient has been recently inoculated prophylactically. Unfortunately the commencement of the injections after infection is of less value, and death frequently occurs, though they should always be given, as they seem of value in slowly developing cases. As a prophylactic it is of undoubted value both in animals and man, and should be given in all countries where rabies is endemic; it is only effective for about six months.

The method of treatment was introduced in 1885, and the results on the whole have been most successful. The method employed is briefly as follows:

A virus of maximum intensity is produced by injecting an extract of the pulped spinal cord of an infected animal in sterile broth into the subarachnoid space of rabbits, or better, dogs, until the animals die regularly on the seventh day, all parts of their spinal cord being then equally virulent. The cords are then removed and hung in a chamber over caustic soda to dehydrate, and gradually lose their toxicity, being harmless in fourteen days.

Individuals are inoculated with preparations obtained by pounding these cords in sterile broth, the injections starting with the weakest and gradually working up to cord that has only been dehydrated one day. The course of treatment usually takes six weeks, but a more rapid though not so certain method can be adopted if necessary.

When once the disease has manifested itself only palliative measures can be adopted, the patient being kept quiet in a dark room and under the influence of narcotics. Rectal feeding is usually necessary.

(c) ANTHRAX

Anthrax is primarily a disease affecting horses, cattle and sheep and producing in these a generalised septicæmia, which is known to veterinary surgeons as " splenic fever," owing to the marked splenic enlargement seen in this condition. The disease can be conveyed to man and is most often seen in either those whose occupation leads to their handling animals, such as veterinary surgeons, butchers and herds, or those whose business leads to their handling furs or hides. Thus it is common among carders and spinners, where the bacillus is often inhaled and gives rise to a septic broncho-pneumonia known as "woolsorter's disease"; and again among tanners, where the bacillus usually enters through an abrasion on the hand, forearm, or face, and gives rise to a local infection, "malignant pustule," or a generalised one, "anthrax œdema."

The disease is due to B. anthracis, which is a very large (6–10 μ) Gram-positive and aerobic bacillus which occurs in chains, and which is capable of forming very resistant endospores; these readily grow under favourable conditions, and they are very difficult to destroy in this form. This organism is thus a serious menace to the surgeon, and after a case of anthrax has been treated, all dressings, etc., must be destroyed by burning, and all instruments boiled for at least ten minutes on two successive occasions, at least an hour elapsing between the two boilings.

Woolsorter's disease does not really come under the care of the surgeon; the pulmonary type can only be diagnosed from other forms of broncho-pneumonia by the discovery of B. anthracis in the sputum. It is usually rapidly fatal. There is an intestinal type, somewhat resembling cholera in the rapidity of its onset, with cramps, bloodstained diarrhœa, and rapidly fatal termination. The causative organism can be recovered from the stools.

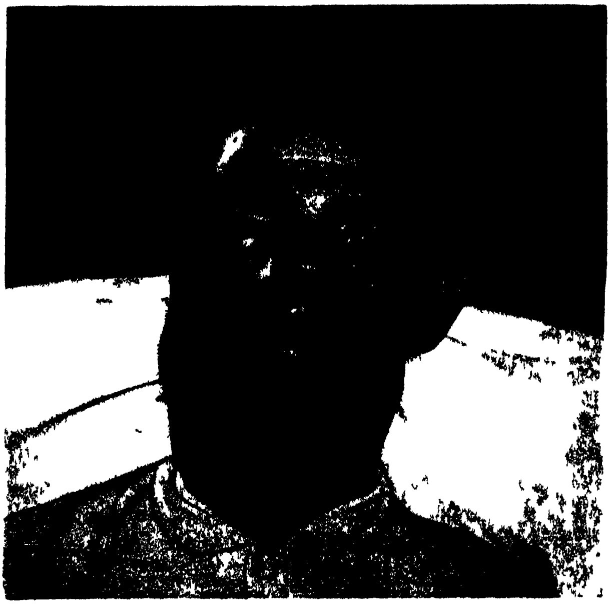


FIG. 31. Malignant pustule on the lip. The central slough surrounded by vesicles can be seen, while the characteristic great œdema of the surrounding tissues is noticeable.

Malignant Pustule. This form of the disease, as already stated, is usually met with in those handling hides, and results from the infection of an abrasion, usually on the hands, forearms or face; on the chin it is often due to infection from a new and infected shaving brush. The B. anthracis can always be obtained from the primary lesion and the neighbouring lymph nodes.

The lesion starts on the seventh day after infection as a reddish papule surrounded by a ring of blanched skin, which would appear to be pathognomonic of "malignant pustule." This papule increases in size steadily, becomes indurated and angry; on about the third day vesiculation occurs, the fluid being dark red or black in colour. Umbilication of the vesicle rapidly follows, the depressed area scabbing over about the fifth day, when also considerable dusky discoloration and œdema begin to manifest themselves in the surrounding tissues. Typically the pustule is surrounded by a concentric inner zone of infiltration with a large zone of œdema for some inches round this. The vesicle increases in size till the eighth day, after which it dries off and the scab comes away, healing being complete by the twelfth or fourteenth day. Throughout the whole period there is intense itching of the lesion, and anthrax bacilli can be obtained on puncture both of the papule and vesicle. More than one primary lesion may be present, usually on the forearm, hand or face, and many smaller vesicles may appear around the first after scratching, which is liable to occur because of the irritation. Serum administered early will much alter the severity and time of persistence of the local pustule. There is usually very little constitutional disturbance, but occasionally there may be high temperature (103° F.), lymphangitis and gastro-enteritis. These latter cases, particularly common after shaving infections, are usually fatal in a few days.

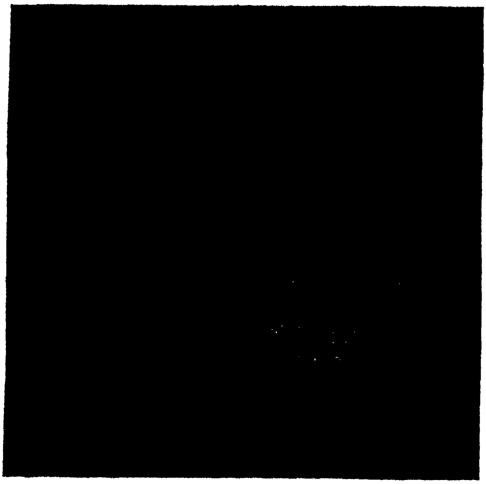


FIG. 32. Anthrax pustule.

The condition of local inflammation usually remains sharply localised to the affected part, but in unfavourable cases the œdema spreads rapidly all over the body, there is acute septicæmia, and the patient quickly collapses and dies (**anthrax œdema**).

The *differential diagnosis* is usually not a serious matter, but there are two conditions which may cause some difficulty:—

(i.) An acute staphylococcal infection of the cutis; here the local reaction is not usually so intense, nor the constitutional disturbance so marked, but in some cases a definite diagnosis can only be given after a microscopical examination of the fluid from the vesicle.

(ii.) Accidental vaccinia may simulate malignant pustule very closely, and here the history and the absence of the typical bacillus alone can clear up the diagnosis.

The *treatment* of malignant pustule is a question on which there has been some divergence of opinion, for whereas some surgeons strongly advocate excision of the primary lesion, others depend entirely upon the action of serum, and it must be admitted these latter get equally good results; personally we do not recommend any surgical interference with the pustule. Certainly in all cases serum should be administered, that usually employed being Sclavo's, which is obtained by inoculating goats, previously rendered immune by Pasteur's vaccine, with large doses of virulent cultures; the dose is 24–40 c.c. (340–680 m.); it is given at once and should be repeated for the next three days (1st day 40 c.c., 2nd day 30 c.c., etc.).

Sobenheim's serum in the same doses may also be employed, but is not in our experience so satisfactory. The injection is usually followed in either case by a brisk general reaction and rapid improvement in localised pustules. The generalised forms of anthrax are fatal in spite of treatment.

(*d*) GLANDERS

Glanders is primarily a disease affecting the mucous membranes, and contiguous lymphatic vessels and nodes in the horse and ass, which may be acquired by persons whose occupation brings them in close contact with these animals. The disease is due to the Bacillus mallei, an organism somewhat resembling the tubercle bacillus in appearance, but which shows a characteristic brown growth with a greenish margin on potato, and is Gram-negative.

A vaccine known as "mallein" is much used as a means of diagnosis by veterinary surgeons, a sharp rise of temperature following its injection in cases of glanders.

(*a*) *In the horse* the disease may be either acute, or chronic; in the latter case it is known as farcy.

Acute glanders is almost always primarily seen in the mucosa of the mouth or nose, which is red and injected, and shows the typical firm and translucent greyish nodules in the submucosa. These rapidly break down and ulcerate, giving rise to a sanious discharge mixed with watery mucus from the surrounding œdematous mucous membrane. This discharge is full of B. mallei and is highly infectious. The ulcers penetrate deeply and destruction of bone and cartilage soon occur. The cervical lymphatics are enlarged and corded, and the lymph nodes are the seat of secondary nodules, which sooner or later break down and ulcerate through the skin. Dissemination with multiple abscess formation in the lungs, liver and spleen soon leads to a fatal termination. the animal becoming much emaciated during the progress of the disease.

Chronic glanders (farcy) follows infection through a skin abrasion, in the site of which a chronic ulcer, showing considerable induration in its base, develops. The surrounding lymphatic vessels become involved and can be felt as hard corded strands running under the skin, the so-called "farcy pipes." The lymph nodes become infected, large and adherent, forming "farcy buds"; these soon break down and give rise to numerous ulcers,the discharge from which is very infectious. The disease lasts four to six months, and about 50 per cent. of the infected animals recover, though convalescence is slow.

(*b*) *In man* the disease is always more or less acute and invariably results from infection through an abrasion either of the skin or nasal mucous membrane. There is an intense inflammatory reaction around the seat of inoculation, usually with vesication, and the neighbouring lymph nodes are enlarged and tender. The patient shows marked constitutional disturbance. The area soon breaks down and ulcerates, giving rise to a foul sanious and highly infectious discharge, and in the case of infection in the nose, the septum rapidly ulcerates and is destroyed. Ulceration of the infected lymph nodes also occurs. Rarely pyæmia, with multiple lung, liver and splenic abscesses, occurs —these cases are always fatal. " Farcy pipes " are not met with in man.

The *diagnosis* may present some difficulties, but is at once cleared up by the finding of the B. mallei in the discharge.

The vesicular condition may be confused with small-pox, but no umbilication is present in glanders, there is marked involvement of the subcutaneous tissue, and the lymph nodes are enlarged and tender.

The nodular and ulcerative stages need to be differentiated from syphilis and tubercle, and in cases where the nasal septum is destroyed lupus and chromic acid poisoning must be eliminated. Usually the history of working with an infected animal is easily obtained, and once ulceration has occurred the B. mallei can be found in the discharge.

Injection of mallein for diagnostic purposes has been advocated, but the resulting reaction is very severe, and the complement-fixation test is safer and equally satisfactory.

The *prognosis* is very grave, the mortality being in the region of 60 per cent.

Treatment consists in the early stages in the excision of the infected area, and later in opening abscesses and curetting ulcers as necessary.

Great care must be taken that all contaminated dressings are destroyed, and it is wise to dress such cases in rubber gloves.

Mallein has been tried as a curative agent with poor success, and its use is not advocated.

(*e*) LEPROSY

This is a disease rarely seen in the British Isles, though it is commoner than is perhaps generally appreciated, and although it usually occurs in persons who have acquired the disease abroad, often in Scandinavia, there are a few undoubted cases known in which infection has been acquired in this country. The condition is an infection from the Bacillus lepræ, which invades primarily the skin and peripheral nerves, leading to a peripheral neuritis with subsequent trophic lesions.

The B. lepræ closely resembles B. tuberculosis, both in appearance and in being acid fast when stained by the Ziehl-Nielsen method: it is very doubtful if the organism has ever been grown in culture.

The disease used to be common in England, but is now confined to Iceland, the Scandinavian countries, Russia and the East, and is believed to result from the eating of badly cured and decomposing fish. The disease seems to be very slightly contagious and is rarely, if ever, transmitted to descendants.

Clinically two distinct forms of the disease are met: (1) nodular; (2) anæsthetic.

(1) **Nodular or cutaneous leprosy** is commoner in this country and in Europe —usually manifesting itself months or years after infection. The disease has

a gradual onset, accompanied by slight malaise and febrile disturbances; this is followed by the appearance of bright red hyperæmic spots, usually situated along the course of one or more peripheral nerves. The affected areas are infiltrated and hyperæsthetic, usually appear first on the forehead, thighs and forearms, and tend to occur in crops, each of which is accompanied by febrile disturbance. After a short time the nerves can be felt to be definitely thickened in portions of their course, and the skin becomes rough and tuberculated, and ultimately of a reddish brown colour. The lymph nodes are frequently enlarged, and sexual functions become lost in both sexes.

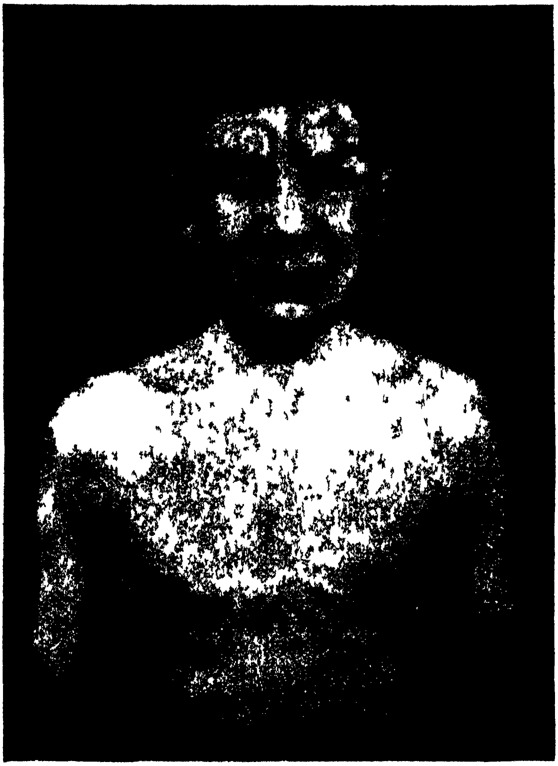


FIG 33. Hypertrophic (nodular) leprosy, with pigmented spots on arms

Later the skin areas may ulcerate or atrophy, but marked anæsthesia is not usually present. The nodules and lymph nodes are found to be full of granulation tissue, among which lie large clear cells containing vast numbers of bacilli.

(2) **Anæsthetic leprosy** is more commonly met with in the East and tropics. The onset is similar in type to the nodular form, but often associated with stabbing pain along the course of the cutaneous nerves, of which the ulnar and saphenous are most commonly affected. This is followed by anæsthesia and muscle weakness in the affected parts, with rapid onset of trophic changes in the skin; this becomes smooth and yellowish white in colour, firstly in patches, but, as these coalesce, in large areas, which become parchment-like, anæsthetic and tend to break down as a result of trauma or infection, with the formation of slowly-spreading trophic ulcers. Bones often become absorbed in the hand and foot, and this, together with wasting and contraction of muscles,

gives rise to characteristic deformities, and even to loss of fingers and toes. The affected nerves are usually uniformly enlarged and tender to palpation.

Both forms of the disease usually last from ten to thirty years, death ultimately occurring from pulmonary complications or general debility resulting from chronic sepsis.

Treatment, though much more satisfactory than previously, still leaves much to be accomplished, it being very common to meet with relapses in so-called cured cases. The most popular remedy is Chaulmoogra oil administered both internally and externally.

Vaccine treatment as advocated by Sir Leonard Rogers has been tried with success; nodules are excised and desiccated to kill the bacilli, and the whole emulsified with sterile broth, and injected in increasing doses weekly till a definite reaction is obtained. Nastin, a neutral fat extracted from the nodules, is also injected hypodermically, and some successes are reported.

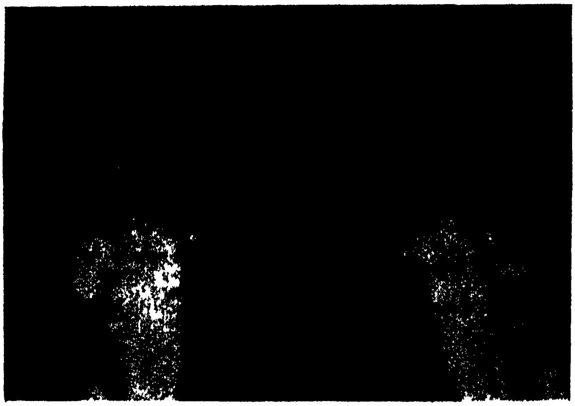


FIG. 34. X-ray photograph of the hands in anæsthetic leprosy showing the symmetrical absorption of the bones.

Amputation may have to be resorted to in some cases.

Patients should be segregated, or their relations warned of the remote possibility of infection by contagion.

(*f*) DIPHTHERIA

Diphtheria is an infectious disease due to infection with the Bacillus diphtheriæ (Klebs-Loeffler) and is characterised by the formation of a tough whitish fibrinous membrane at the seat of the infection, which membrane cannot be separated easily from the underlying tissues, and attempts at the removal of which cause bleeding from the necrosed superficial epithelium.

The bacillus is a short non-motile Gram-positive organism which stains irregularly, more so at the poles, and thus presents a beaded appearance; it remains localised to the site of infection, but gives rise to an exo-toxin which is absorbed into the blood, and causes fatty degenerative changes in the tissues, especially the heart and muscles, and by its action on nerves causes muscular weakness and palsy, which further aggravate the cardiac disease.

The membrane usually appears in the pharynx, whence it spreads to the larynx and bronchi, producing œdema of the glottis, and urgent dyspnœa, which may necessitate tracheotomy or intubation for its relief (see Vol. II., Chapter IX.).

The disease may be present in the nose, when it is characterised by a foul sanious discharge containing portions of membrane, and may spread thence *via* the nasal duct to the conjunctiva, a serious complication usually resulting in blindness.

The disease is also rarely seen in the vulva of debilitated girls (where it constitutes a form of noma, see p. 163, Chapter VII.), and about the glans penis in boys; in both cases it is usually fatal.

Very occasionally the disease may manifest itself in a surgical wound.

The *diagnosis* is established by the identification of the Klebs-Loeffler bacillus in the lesion, and in this connection it must be borne in mind that a person may have actively toxic bacilli in the tonsillar and pharyngeal crypts and yet show no signs of the disease, though capable of infecting any number of people. Such a one is a *carrier* and should be looked for in any diphtheria epidemic. *Immunisation* by serum is now extensively and successfully employed as a prophylactic against the disease.

Treatment consists in the prompt injection of diphtheria antitoxin, which is given intramuscularly in doses of from 8,000 to 50,000 units (usually 12,000); the dose can be repeated, if necessary, on the second and third days. The membrane separates rapidly after this and both local and general symptoms ameliorate, but owing to the cardiac condition, the patient must be kept absolutely at rest for several weeks, as syncope and sudden death not infrequently follow too early movements.

Antiseptics may be applied locally and the area be cleansed regularly by syringing.

For the relief of the dyspnœa, tracheotomy or intubation by O'Dwyer's method may be necessary (Chapter IX., Vol. II.), the latter method only being safe in cases where the doctor remains at hand, as the tube may be coughed out and need rapid replacement. Tracheotomy should not be too long postponed in cases where dyspnœa is persistent or increasing, and the child showing signs of exhaustion; except in cases of great urgency the low tracheotomy is to be preferred as it is farther from the site of infection, and less likely to cause subsequent stenosis.

III. INFECTIVE GRANULOMATA

These are a group of diseases the characteristic lesion of which consists primarily of a mass of granulation tissue, among which can be found a varying number of multinuclear giant cells and the ætiological organism of the disease. Later the toxins emanating from the organisms lead to death of the tissues and the formation of a slough, which, from its structureless and yellowish white appearance, receives the name of caseous material; the process is known as *caseation*. The dead material later becomes broken up and partially liquefied by the inflammatory exudates from the surrounding living tissues, and is then known as caseous pus, though this differs from true pus in that the cells in the exudate are mainly small lymphocytes and not leucocytes.

(*a*) TUBERCULOSIS

Tuberculosis is a disease which results from the infection of any of the tissues of the body with the Bacillus tuberculosis, and derives its name from the small semi-transparent greyish white tubercles, the appearance of which is characteristic of the disease.

The Bacillus tuberculosis was first isolated and cultivated by Koch; it is a long, slender, slightly-curved bacillus, which usually occurs in clumps and may show branching, so that it is thought by some observers to be closely allied to the streptothrices. The organism can be grown fairly easily either on potato and glycerin, when it shows a greyish scaly film, or on special media, the chief ingredient of which is egg-albumen; the bacillus shows characteristic staining reactions to the Ziehl-Nielsen method being both acid- and alcohol-fast, which latter reaction distinguishes it from the smegma bacillus met with in the urine in both sexes.

It is generally admitted that there are two distinct varieties of the bacillus, the human and the bovine, both of which are capable of producing lesions in the human body, but it is improbable that the avian variety is pathogenic to man. The *human variety* is commonly met with in lesions in the lungs and in generalised miliary tuberculosis, whereas the *bovine* type, ingested as it usually is through the intestinal canal as the result of drinking milk from infected cows, is commonly met with in lesions of the bowel, peritoneum, glands, bones and joints, and is, therefore, of more interest to the surgeon than the human variety. The two types can be differentiated readily by culture on egg medium, when the bovine type grows very poorly, whereas the human gives an abundant growth. Again, the bovine type is very toxic if injected into rabbits and guinea pigs, whereas the human rarely, if ever, causes death.

The organism may gain access to the body in three ways:

(i.) By *inhalation*. The sputum of persons suffering from pulmonary consumption (phthisis) is full of B. tuberculosis, and if voided indiscriminately, becomes inspissated and liberates numerous bacilli which adhere to moist dust particles in the atmosphere and become inhaled. It is therefore essential that the sputum of phthisical patients should be collected suitably and destroyed immediately it is voided, for which purpose some form of covered spittoon containing 1 in 20 carbolic acid, which readily destroys the bacillus, should be provided. The inhaled organisms may get caught in the crypts of the tonsils, pharyngeal lymph nodes, or in carious teeth, whence they infect the cervical lymph nodes, or else pass down and infect the lungs and lower respiratory passages, and thence the bronchial and mediastinal nodes. Inasmuch as pulmonary disease is due nearly always to the human variety of the bacillus, it follows that the resulting infection is of that type in nearly all cases of inhalation.

(ii.) By *ingestion*. Cows are particularly liable to tuberculous infection of the udders, and thus milk is frequently infected with bovine tubercle, which may infect any part of the intestinal canal and adjacent lymph nodes. Inasmuch as milk is the staple diet of young children, the bovine variety of the disease is more commonly met with at this age.

The primary lesion may be in the tonsils or carious teeth, with secondary infection of the cervical nodes, or in the Peyer's patches of the small intestine, with secondary infection in the peritoneum and lymph nodes, or should dissemination occur, in any body tissue, the growing ends of bones and joints being particularly susceptible.

(iii.) By *inoculation*. This cause is rare, but occasionally infection may occur *via* a cut accidentally inflicted by a broken sputum cup, or on the arms of butchers who handle infected carcases, when it forms a warty growth known as Verruca necrogenica (p. 236).

It is doubtful if the bacillus ever flourishes in normal healthy tissues, where it is rapidly destroyed, but if the tissue vitality is lowered, either by recent slight injury, or by the presence of long-standing chronic inflammation and fibrosis, then the organism can gain a satisfactory foothold and multiply. It is very doubtful if heredity plays any part in predisposing to the disease, but a generally poor state of health, and unhygienic surroundings, especially if there is close association with tuberculous patients, undoubtedly render people more prone to infection; this is shown by the appalling spread of tuberculosis which occurs in the winter months in South-East Europe, where, owing to inclement weather, the inhabitants remain closely shut up and grossly overcrowded for weeks in ill-ventilated, ill-lit, warm and dirty hovels.

The disease is particularly prone to attack people at the extremes of life, but whereas in children recovery is the rule, the prognosis in senile cases is very grave.

The *pathological anatomy* of a tuberculous lesion with advantage may be discussed here, as whatever the tissue invaded, the lesion produced following the successful lodgment of the B. tuberculosis is the same in all situations. The characteristic lesion so produced is the **miliary tubercle,** which is about the size of a pin-head or slightly larger, and which can be readily detected by the naked eye as a soft, semi-translucent mass of a greyish white colour lying among the tissues; usually these nodules are multiple. Shortly they coalesce and undergo a process of fat necrosis known as *caseation,* from the action of the bacterial toxins causing obliteration of the vessels, with subsequent death of tissue cells, and forming areas of varying size, structureless and opaque to the eye, and whitish in colour. Should such an area be examined microscopically, the typical translucent nodules will be found around the edges of the necrosed area, though frequently they are not discernible to the naked eye.

At a later stage several of these caseous areas coalesce, and considerable masses of whitish caseous material of a cheesy consistency may exist in the affected area; these may either—

(1) Be partially liquefied by the action of the serum from the surrounding tissues; in which case they break down and form a *chronic abscess,* the cavity of which is filled with liquefied caseous material, usually of a thick creamy consistency, and in which occur masses of solid slough as yet unaffected, the whole having an appearance very like curds and whey, and forming the so-called tuberculous pus; the abscess wall consists of a lining of granulation tissue containing innumerable tubercles, and surrounded by a zone densely infiltrated with masses of small lymphocytes; or

(2) Become encapsuled with fibrous tissue, as a result of the reaction of the surrounding tissues to the infection: then after a time the mass of caseous tissue becomes inspissated from absorption of its contained water and later undergoes *calcification,* with persistence of the calcified mass in the midst of the fibrous tissue; or if the area is small absorption of the whole of the inspissated caseous material may occur, the lesion being subsequently represented by a dense fibrous cicatrix, among the elements of which persistent and densely encapsuled tubercles may be demonstrated microscopically.

In all cases care must be taken not to break down the lymphocytic and fibrous barriers, as should this occur, dissemination and generalised infection may result. Should the lesions occur near the surface, the overlying skin or mucous membrane may break down and a typical *tuberculous ulcer,* with its undermined and cyanotic edges and abundant pale granulations, develop (see Chapter VII., p. 151).

It is obvious that the areas of dead and inflamed tissue are very liable to secondary infection with pyogenic organisms, as there is but little or no local resistance. Every care should be taken to avoid this very serious and all too likely complication, and should it occur, energetic measures must be taken to deal with the resulting acute inflammatory lesions on the lines laid down in Chapter V.

The *microscopical appearance of a tubercle* in the early stages is very characteristic and is best studied by cutting a section from a tubercle from the meninges in tuberculous meningitis. In the centre of the mass is a giant cell, which from its large size in comparison with the other cells forms the outstanding feature of the microscopic field. It is usually oval in shape and contains several oval nuclei which are arranged in a horse-shoe manner around the periphery, the centre of the cell being clear, and staining homogeneously.

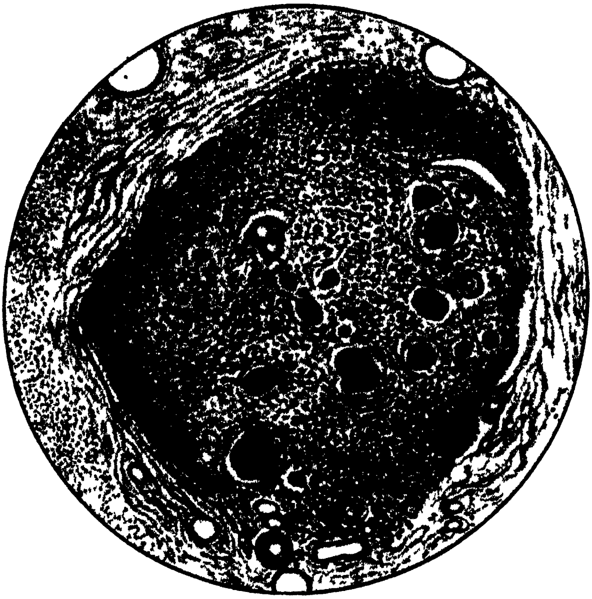


FIG. 35. Tuberculous focus showing giant cells and lymphocytes (× 52).

Tubercle bacilli may be present in or around this giant cell, but are very frequently not met with; again, the giant cell itself may be absent, especially in acute cases. Around the giant cell, or replacing it when it is absent, are several layers of largish mononuclear cells, known as endothelioid cells, and beyond this are dense masses of small mononucleate cells, circular in shape, and with very little cytoplasm around the nuclei; these are small lymphocytes. Farther out these become interspersed with the tissue cells, and in the later stages fibroblasts are also present.

It may not be out of place here to mention that a granulomatous mass of this nature may be met with in the tissues as the result of a feeble reaction to any chronic irritation, such as results from an unabsorbed ligature, as well as the other granulomata—syphilis, actinomycosis, etc. Moreover, the presence of a giant cell does not necessarily mean that the lesion is tuberculous in origin, though if the horse-shoe arrangement of the nuclei is present it is very usually tuberculous. Giant cells occur sparsely in syphilitic lesions, and are also met with (1) in bone marrow and myelomata (osteoclastomata), where the nuclei are clumped in the centre of the cell, which is known as a *myeloplaxe*: (2) in rapidly growing cellular tumours, such as sarcomata, where the nucleus is usually single or very imperfectly differentiated; (3) in lymphadenoma.

The exact development of the tubercle has not been fully worked out, but apparently the bacillus lodges in a lymph space or small capillary and causes an irritation of the wall with multiplication of the endothelial cells, the giant cell being apparently derived in some manner from rapid division of nuclei in these without differentiation of the protoplasm. The exact source of the lymphocytes is uncertain, but they appear to be formed locally.

The exotoxin of the bacillus causes obliterative endarteritis, and also assists in the death of the tissue cells, which by a process of fat necrosis become converted into a structureless mass, known as caseous material from its superficial resemblance to cheese; this may be surrounded by a layer of fibroblasts, among the cells of which there is much exudation of serum containing lymphocytes, the whole, to the naked eye, presenting the characteristic gelatinous and œdematous appearance so characteristic of the tissue around a tuberculous focus.

Clinically, the presence of a tuberculous focus is to be suspected, especially in children and old persons, when a swelling of a diffuse nature is present in the tissues, with a slight general increase in the local temperature, and a history of gradual onset, no redness being present, a fact which earned for tuberculous lesions among the older surgeons the well-deserved name of *white swelling*.

Inasmuch as the physical signs of such lesions vary greatly according to the tissue in which they are situated, a detailed description is out of place here; they are discussed under the appropriate headings (Bones, Chapter XVIII.; Bowel, Vol. II.; Joints, Chapter XIX.; Urinary, Vol. II.; Genital, Vol. II.; Lymph Nodes, Chapter XI.; Spinal disease, Vol. II.).

The *diagnosis* of the condition may present some difficulties, and has to be made from other chronic inflammatory conditions of a similar nature, especially syphilitic and chronic pyogenic infections, and lastly from post-traumatic lesions, a condition in which tuberculous infection not infrequently supervenes. The question of differential diagnosis will be dealt with in detail under the various local tuberculous lesions, but a few general remarks may be offered here as to the value of a thorough examination of the patient for the presence of tuberculosis elsewhere, and of the various uses of tuberculin both in diagnosis and treatment. In all cases of doubt some of the infected material should be injected into a guinea pig, which will show signs of infection and tubercle formation in from three weeks to a month.

Tuberculin, as prepared by Koch, is of two varieties: (*a*) *Old tuberculin*, prepared by filtering the bacilli off from a glycerin broth culture and diluting the filtrate, which thus contains only exotoxins. This has been used in treatment, where it proved a complete failure, but is still used in diagnosis, the various reactions being of value in the case of a negative result, but of little use in positive cases; for firstly there is great danger of contamination both of the reaction and control, and secondly the vast majority of adults have some active or old lesion, and in either case give a reaction which is positive.

The various tests are as follows:—

(1) *Von Pirquet's*, in which a scratch is made on the cutis and inoculated with a drop of 20 per cent. old tuberculin, when if positive an erythematous blush occurs in the lesion in about twenty-four hours.

(2) *Calmette's*, in which a drop of 1 in 200 old tuberculin is placed in the conjunctival sac, when a violent conjunctivitis results in positive cases; as this often leads to sloughing and loss of the eye, this test should never be used.

(3) The *Mantoux test*, in which the tuberculin is injected intradermally, a positive result being given by the appearance of a local erythematous area.

It will be seen, therefore, that these reactions are of little value in practice, and inasmuch as two of them are by no means devoid of risk, they are best neglected.

(*b*) *New tuberculin* is prepared by grinding up dried bacilli in glycerin and water, and then separating the fluid by centrifugalisation, this being known as tuberculin ober (T.O.) and proving of little value as a therapeutic agent. This process is repeated, and when no residuum remains the washings (except the first T.O.) are mixed, and the resulting tuberculin residuum (T.R.) is much used in treatment.

This can be prepared from either human or bovine bacilli, but is usually used as a mixture of each; it is injected subcutaneously at about ten-day intervals, starting with a very small dose, about ·00001 milligram, and doubling this each time till a local reaction is obtained, when the dose is kept the same till no reaction results, and then pushed cautiously till reaction results and so on. Injections can be controlled by the opsonic index.

This method has had some success in the treatment of genito-urinary and bone tuberculosis (with sinus), and is worth trying in cases where operation is out of the question and as an adjunct to operative measures, but is contra-indicated in cases of pulmonary disease and infection of lymph nodes.

Treatment of necessity varies with the position of the lesion, but certain general principles can be laid down as common to all tuberculous foci.

Firstly it is essential that the affected area should be kept at *absolute rest*, if this is any way possible, and this must be maintained at least six months after all signs of active disease have ceased to manifest themselves. It is obvious, therefore, that the efficient treatment of a tuberculous lesion is a matter of a year or eighteen months, and it is as well to caution the patient's relatives of this at the outset. Where possible, immobilisation is best obtained by the application of plaster of Paris splinting, which can be accurately adjusted to the part, and is not liable to slip or move; it must be remembered that wasting follows immobilisation, and that it is usually necessary to renew the plaster at the end of the first month in order to compensate for this and ensure continuance of complete immobilisation of the diseased area.

The possibility of irritation and secondary infection by other organisms must be guarded against carefully, especially in glandular cases, and so all septic foci, such as carious teeth, inflamed tonsils and adenoids, vermin, etc., need early and efficient removal.

Counter-irritation, with resulting hyperæmia, is advocated by many authorities, but its value is doubtful, and it certainly should never be resorted to at the expense of immobilisation. Blisters, tincture of iodine, Scott's dressing and Bier's passive hyperæmia induced by bandage or suction bell may all be employed for this purpose.

General treatment by giving ample food, general rest, and plenty of pure fresh air is a very essential adjunct to the local treatment, and patients should be sent to institutions in the country or at the seaside.

It must not be forgotten that tuberculosis in all its forms is a *notifiable infectious disease* and that there are special medical officers in each district to assist in the disposal and treatment of all such cases.

Operative treatment should be resorted to in this country only when efficient conservative measures have failed to arrest the disease, and should such measures appear to have been unavailing it is well for the practitioner to ask himself as to their undoubted efficacy in eliminating all movement and irritation before advocating operative interference; for all too often there is some source of incomplete rest present, such as a wasted limb loose in a splint, a surreptitiously lifted extension, or a persistent septic focus, the remedying of which will cause amelioration of the disease in apparently the most hopeless cases. In countries where less civilised modes of life and no means of procuring long rest exist, it is often justifiable and even advisable to resort to the knife immediately, without any attempt at conservative treatment, which it is impossible to carry out efficiently under existing conditions.

When failure of efficient conservative measures is indicated by the persistence of pain and temperature and the formation and enlargement of tuberculous abscesses, then the time has come for prompt surgical interference in order to prevent these breaking through the skin and becoming secondarily infected with pyogenic organisms, which cause the persistence of sinuses and not infrequently lead to the development of amyloid disease.

Tuberculous Abscess. Wherever possible the whole focus should be extirpated, and it is surprising how extensive an area, often containing much caseous material and pus, can be dissected out and removed in toto with a little patience and care. If, however, the skin over the area is bluish and thin or the abscess is in a situation which prohibits extirpation, the cavity should be opened, the walls well curetted to remove granulation tissue, the cavity filled with some antiseptic, such as strong hydrogen peroxide, or bismuth paste (which we personally do not advocate), and then completely closed and obliterated by means of catgut stitches or external pressure. Drainage must *never* be used, as this results in secondary infection and a persistent sinus ; for the avoidance of this also the incision should never be placed over the most prominent or dependent point of the abscess, as should it refill it will tend to point downwards from gravity, and such an incision will tend to open and lead to a sinus.

Aspiration may be practised and is much advocated by Sir Henry Gauvain, though many persons are unable to obtain his excellent results by this method, as, firstly, the pus is often too thick to emerge through even a large aspirating needle, and that even after fluid has been injected to liquefy the pus ; and secondly, sinuses are apt to develop in spite of all care, such as inserting the needle obliquely, and avoiding puncture at the most prominent or dependent points of the swelling. In some cases good results are obtained, and this method should always be tried in those situations, such as psoas abscess, where the primary focus is hard to approach and the results of open operation are known to be disappointing.

In dealing with a "**persistent sinus**" care must be taken to explore this thoroughly, as non-healing often results from the persistence of a small mass of calcified caseous material in its depths, and no useful purpose will result from any operation which fails to remove it. Excision of the whole track, with its fibrous walls, is more likely to be successful than curettage in effecting a cure.

Where large areas of skin over an abscess are bluish and thin, this skin may as well be removed at once, for it will only give way if left, and the abscess thus be converted into an ulcer. Ulcers should be excised if feasible, or if not their floor must be curetted thoroughly and dressings carried out under strict aseptic precautions.

X-rays and ultra-violet rays are of considerable value in procuring the healing of superficial tuberculous lesions, but are of more doubtful value in deeply seated disease, though exposure to ultra-violet rays in the actual or artificial sunlight undoubtedly does effect great improvement in joint and peritoneal infections, and is particularly valuable in cases where a mixed infection and sinuses exist.

(b) SYPHILIS

Syphilis is a contagious disease restricted to human beings, usually acquired during sexual intercourse and due to an infection of an epithelial abrasion by the Spirochæta pallida (Treponema pallidum). The disease was unknown in Europe before 1493, when it was introduced into Spain by Columbus and his sailors on their return from the West Indies, and since then it has spread rapidly and is now endemic the whole world over.

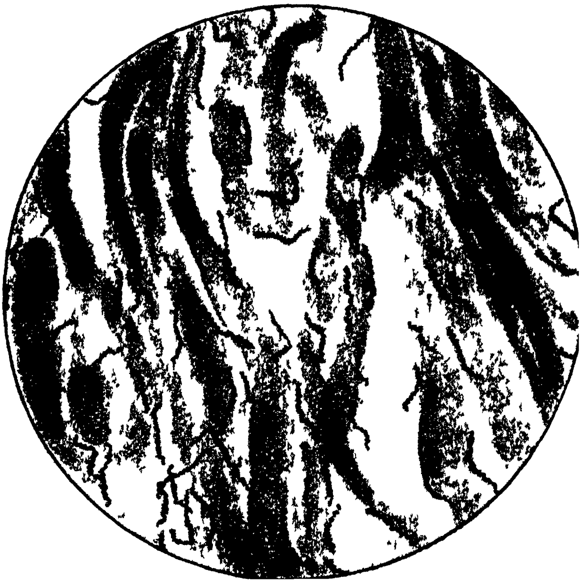


FIG. 36. Treponema pallidum in heart muscle (× 1,500).

The infection, although met with only in the human race, can and has been transmitted to the higher apes, where the experiments of Metchnikoff, Roux and Neisser have shown not only that the disease runs a clinical course exactly similar to that seen in man, but have recovered the Treponema pallidum from the lesions, and demonstrated that it can be transmitted from all kinds of syphilitic lesions, the blood of infected patients, and all portions of the central nervous system of general paralytics. During the primary stage, the milk, saliva, and tears are not capable of conveying the disease unless contaminated by the discharge from the chancre, but these fluids are infectious during the septicæmic secondary stage and in this relationship it must be borne in mind that the saliva is frequently contaminated with spirochætes from mucous patches in the mouth, and therefore must be regarded for all practical purposes as infectious.

The *Spirochæta pallida* (Treponema pallidum) has only been recognised as the causative organism since 1905, when it was discovered by Schaudinn and Hoffmann. It is a delicate thread-like spirillum about 10 m. long, tapering at each end to terminate in a long cilium, and showing from 10 to 12 twists, which do not vary with movement; it is very difficult to identify, being very fine, very slightly refractile to light, and staining badly, characteristics which serve to distinguish it from the numerous other spirochætes met with in the human body, such as Vincent's spirillum in the mouth, and Spirochæta refringens met with in the discharge from most ulcers. The organism multiplies by longitudinal division and is to be found in large numbers in the primary and secondary lesions in acquired syphilis and in the lesions of congenital syphilis, but sparsely in the tertiary lesions of the acquired disease and in parasyphilitic affections.

In spite of the fact that the spirochæte has been cultivated in vitro, but little is known of the life-history of the organism, and all attempts to immunise against the disease have so far failed, though it has been shown both in man and the higher apes that if the area of inoculation is inuncted with a 25 per cent. calomel ointment even so long as twenty-four hours after infection, the disease can be aborted; moreover, in apes, the injection of an attenuated virus in the form of vaccine does appear to modify the course of the disease.

The *laboratory methods* in use for the diagnosis of syphilis consist firstly in the recognition of the Treponema pallidum in the exudate from suspected lesions; in regard to which it cannot be impressed too strongly on the practitioner that where antiseptics have been applied to a sore, the spirochæte migrates into deeper tissues, and so a negative result may be obtained, whereas if the sore be dressed only with saline before examination, numerous spirochætes will be observed.

As already pointed out, the Treponema pallidum is hard to find, but may be more readily seen by use of the ultra-microscope (dark background illumination), or if this method is not available a similar effect can be produced by mixing the film intimately with Indian ink. For staining, Giemsa's method is the best. In this respect it must be remembered that the obvious and highly refractile and blunt-ended Spirochæta refringens is usually seen easily in all ulcer exudates and should not be mistaken for the smaller and more retiring ætiological organisms of syphilis.

Secondly, the pathologist makes use of the *Wassermann reaction*, or one of its modifications, such as the *Sachs Georgi*, which depends on the fact that in all stages of the disease when the organism is disseminated, and this occurs within a few days of infection, the blood serum and cerebrospinal fluid contain a substance which when incubated with an alcoholic extract of heart or liver removes complement from the mixture. That this *complement fixation* has occurred is shown by adding sensitised red corpuscles (sheep's), when these remain unaltered, instead of being dissolved as in normal serum with unfixed complement present.

A positive Wassermann reaction is obtained in late primary, all secondary, and the early tertiary stages of syphilis, but in old-standing tertiary disease, presenting all the signs of clinical syphilis and yielding only to anti-syphilitic treatment, as many as 30 per cent. of the cases give a negative Wassermann reaction, a fact probably explained by the scarcity of the spirochætes and their encapsulation in fibrous tissue locally in the lesions. A positive Wassermann reaction, moreover, is obtained in certain other diseases, yaws, leprosy, trypanosomiasis (sleeping sickness) and in some cases of malaria, and very rarely and inconstantly in the acute stages of scarlet fever; most of these diseases are tropical in distribution, and therefore in this country a positive Wassermann reaction may be regarded as pathognomonic of syphilis.

Manner of Acquisition. Syphilis may be communicated from one individual to another by direct and intimate contact, usually during coitus, and is then spoken of as *acquired syphilis*; inasmuch as its mode of dissemination is in the vast majority of cases the result of infection taking place through abrasions on the delicate mucous surfaces of the genitals, which are brought during sexual intercourse into that close and prolonged relationship favourable to the transmission of the disease, syphilis is usually rightly regarded as a venereal disease. It must be remembered, however, that the disease is very occasionally acquired otherwise, and in these cases of *syphilis insontium* the site of the lesion is extra-genital; it may be seen in any part of the body where infection has taken place, such as the finger, lip, tonsil, nipple, etc., according as inoculation has occurred through an abrasion during examination of an infected patient, while using infected crockery or pipes, suckling an infected child, etc.

It is said that the Treponema pallidum cannot penetrate an intact epithelial surface, infection only occurring when an abrasion is present, but microscopical abrasions in overstretched mucous membranes or skin are probably sufficient to admit the organisms. One attack usually confers immunity.

The infection once acquired can be cured after prolonged treatment, and may be and often is transmitted to the next generation of descendants, when it is known as *congenital syphilis.*

Incubation Period and Stages of Acquired Syphilis. Whether the disease is genital or extra-genital the first sign of infection manifests itself as the *primary sore* at the site of inoculation, usually about three weeks or a month after exposure to infection, though the period may vary from three weeks to three months. It has been shown, however, by the inunction of calomel ointment at the site of inoculation, that the organism only remains localised to the area of infection for at most twenty-four hours, after which it disseminates *via* the blood stream to all the tissues of the body, giving rise to a generalised infection comparable to a septicæmia, which is well established (as is shown by the positive Wassermann reaction), though not always clinically manifested when the primary sore is first noticed.

FIG. 37. Hunterian chancre on penis.

Following the teaching of Ricord, it is usual to describe the clinical manifestations as occurring in three stages, though it must be understood clearly that these are not sharply differentiated, that often two may exist at the same time, and transitional forms are often seen between the second and third stages; moreover, the period of time elapsing between infection and the onset of the second and third stages varies very considerably in different cases, and is furthermore much modified by treatment.

The *primary stage* embraces the period from infection, including the period of incubation and development of the primary sore, with the accompanying characteristic painless enlargement of the nearest group of lymph nodes, to the first development of general constitutional symptoms, and is usually from six to eight weeks in length.

The *secondary stage* lasts from one to two years, and during this period the patient shows a variety of clinical manifestations in various tissues, due to the irritation and toxæmia caused in them by the presence of the causative organisms; the skin, mucous membranes and lymph nodes are particularly susceptible to attack.

The *tertiary stage* follows on the secondary gradually, and inasmuch as, the infection once acquired, it is difficult to rid the tissues entirely of the spirochætes, it has no time limit and may manifest itself throughout the remainder of the patient's life by the appearance of localised granulomatous masses, known as *gummata*, or by a diffuse infiltration of the tissues by small lymphocytes and fibroblasts, with subsequent fibrosis, as occurs in the spinal cord (tabes dorsalis), in bone (syphilitic osteo-periostitis) and elsewhere.

The *clinical picture* presented by the patient in each of these stages varies widely, and therefore each will be discussed separately, but it must be borne in mind that there is no sharp line of delimitation between the stages, the lesions of which frequently coexist.

(1) The **primary stage** is manifested by the development at the seat of inoculation, usually three to six weeks after infection, of an indurated mass of granulation tissue, the **primary sore** or **hard chancre**, the immediate lymph nodes adjoining presenting a characteristic enlargement. It cannot be too strongly impressed on the practitioner that during the period of incubation which precedes the onset of induration of the chancre, the treponema can be obtained from the discharge from the lesions, and it therefore behoves every medical man carefully and promptly to examine any suspected ulcer around the genitalia by taking a scraping for microscopical examination, as the earlier the disease is diagnosed the greater the chances of success in curing it.

In the male the sore is usually situated around the corona or frænum preputii, or at or around the meatal orifice, but it may occur anywhere around the genitalia or on the abdominal wall, and occasionally is situated in the penile urethra. The term " concealed chancre " is applied to one situated beneath a long foreskin and preventing its retraction. In the female the chancre is usually situated on the cervix, about the vaginal orifice or along the labia. There is no doubt that the primary sore, especially in women, fairly frequently escapes the notice of the patient and even of the practitioner.

The type of sore varies somewhat, and three varieties are usually described:

(1) The *Hunterian or ulcerative chancre* is the classical sore, indurated, painless, consisting of a mass of lymphocytes and fibroblasts, situated usually on the glans penis, and subsequent to the process of fibrosis breaking down and ulcerating on the surface, from which a thin serous discharge escapes.

FIG. 38. Ulcerated crateriform chancre on penis.

FIG. 39. Scaly chancre on the scrotum.

(2) The *papular chancre,* usually occurring in the skin and presenting at first a hard raised papule, with a raised surface, not unlike a split pea, the whole being much indurated and painless. As fibrosis progresses, the surface becomes concave following necrosis of the centre of the chancre, and then ulcerated, the floor of the ulcer being covered for a short period with a thin, yellowish slough, and then presenting a clean, granulating surface, from which a clear serous discharge exudes.

(3) The *parchment induration* of Ricord, met with on the glans penis and mucous surface of the foreskin, and vulva; this is easily overlooked, as the induration is very superficial, and the condition also painless.

FIG. 40. Chancre of eyelid.

All these chancres often heal without leaving any permanent scarring, and in examining the genitalia for evidence of old infection this should be borne in mind; scarring. however, results if secondary infection has occurred, and always follows soft chancre (pp. 87 and 152), in which case more than one scar usually exists.

Whichever type of chancre is present, there exists concomitantly the very typical enlargement of the neighbouring lymph nodes—the inner horizontal inguinal group in the case of genital chancre.

These lymph nodes are enlarged, elastic, discrete and painless, and move freely in the tissues, nor do they ever suppurate unless secondary infection is present in the chancre. A primary sore should be diagnosed with great reserve if this enlargement of the lymph nodes is not present, and so characteristic is the condition that should it be present it is fairly safe to diagnose the presence of a syphilitic chancre even though this may not be obvious. This latter is very helpful often in the diagnosis of **extra-genital chancres** (p. 323), which are frequently not indurated, and are thus liable to be treated merely as chronic sores unless the gland condition is looked for and discovered. Such extra-genital chancres, as has already been pointed out, usually occur on the lip, nipple or finger, this last situation being most commonly seen in nurses and doctors, and frequently taking the form of a callous and non-indurated ulcerating slit beside the nail, a condition only too liable to be overlooked unless the presence of the typical glandular enlargement in the axilla is inquired for and elicited. These extragenital chancres, in addition to being softer than the genital type, give rise to very large masses of discrete glands, especially in the axilla.

Secondary infection of the chancre either with pyogenic cocci or the bacillus of Ducrey may occur not infrequently, in which case the lymph nodes usually break down and suppurate, requiring incision; phagedæna of the penis (Chapter VII., p. 163) may occur, in which case energetic treatment on the lines there laid down, by frequent baths and cleansing, will be necessary to preserve the organ.

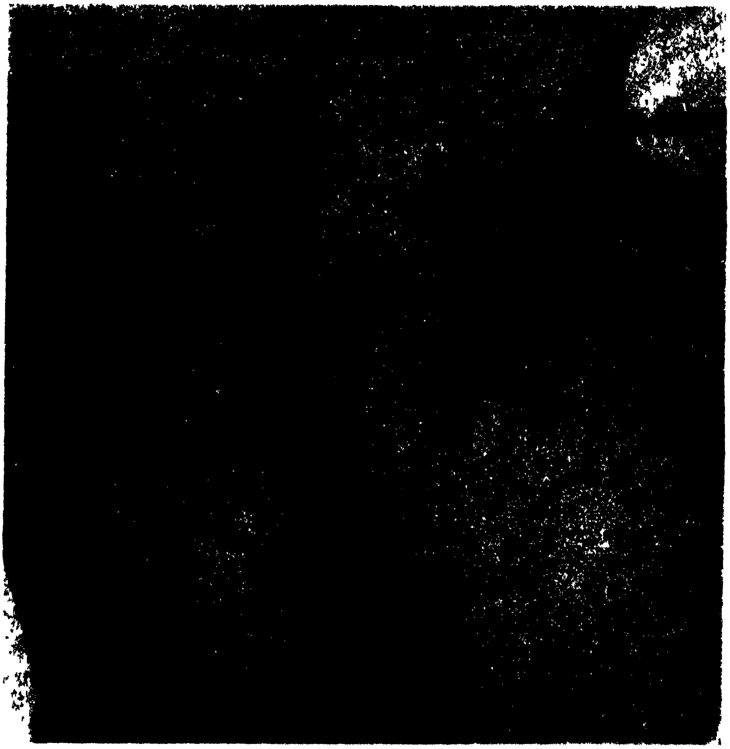


FIG. 41. Secondary syphilitic rash.

The *diagnosis* of a syphilitic hard chancre is usually easy, for it presents the local induration and glandular enlargement as described; occasionally, however, considerable difficulty may be experienced, especially if soft chancre and secondary infection coexist; and in every case very careful examination of the serum from both the ulcer and the lymph nodes should be carried out to isolate the Treponema pallidum, the presence of which when demonstrated clinches the diagnosis.

Relapsing Chancre. This term is applied to the ulceration and reinduration which occasionally recur at the site of a previous primary syphilitic sore, and usually results from the too early cessation of treatment in the secondary stage.

(2) The **secondary stage** usually manifests itself about the eighth week after infection and synchronises roughly with the disappearance of the chancre

though the enlargement of the lymph nodes in the neighbourhood of this usually persists for some weeks longer. As has been pointed out, this stage is really one of septicæmia, and, as would be expected, *constitutional disturbance* occurs, the temperature is frequently intermittent in type, the patient feels "off colour," and general loss of appetite and headache are not infrequent. There is marked anæmia, a blood examination showing deficiency in both red corpuscles and hæmoglobin; there is also a marked lymphocytosis.

There is a generalised slight enlargement of the lymph nodes throughout the body; the epitrochlear nodes in the arm, being easy of palpation, are usually specially noted, and accompanying this are rashes of the skin and mucous membranes with loss of hair (alopecia), and less commonly transient pains and œdema in the bones, joints, genital organs, eyes, etc., depending on the local reaction of these tissues to the invasion by the treponema, which is carried to them in the blood and lymph streams.

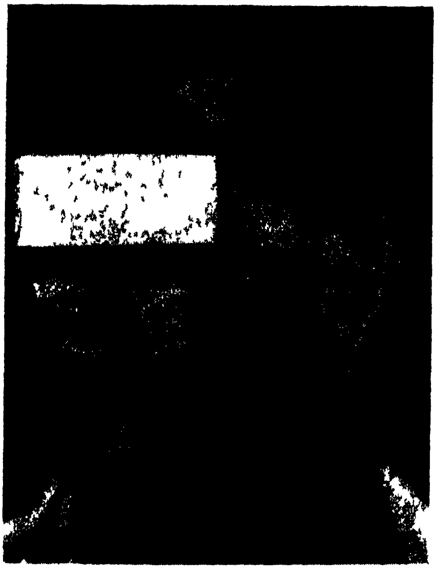


FIG. 42. Secondary syphilitic rash with corona veneris

Following prompt and early treatment of the primary lesion, the secondary manifestations may be aborted, but it must be impressed on the patient that a full course of treatment is essential to prevent the later development of tertiary and parasyphilitic lesions.

The *cutaneous rashes* of secondary syphilis are very varied in their types, and not infrequently are not of the same character throughout the body: they are frequently very difficult to diagnose, but the following points are helpful in determining that a rash is syphilitic :—

(i.) The rash is of a coppery or raw ham colour, and apparently deep to the cuticle, so that it can be more distinctly seen from a reasonable distance than when the head of the observer is approximated to the skin of the patient.

(ii.) The rash is frequently of different types (polymorphism).

(iii.) It does not itch.

(iv.) The trunk is more affected than the limbs, and the flexor surfaces more than the extensor. The rash frequently arranges itself along folds of skin, and thus may be seen radiating from the axillary folds, and is often dense along the creases of the forehead (corona veneris). It is usually symmetrical in its distribution.

The rash may be of various types, many often co-existing; thus there may be a simple patchy hyperæmia, sometimes so dense as to make a dusky patchwork of the skin (roseolar syphilide), a papular rash, and more rarely vesicular, pustular or squamous rashes may be met with.

The *mucous membranes* may be similarly affected, when they appear red and congested, and inasmuch as they are continuously damp, the surface epithelium soon becomes sodden and opaque, forming a **mucous patch,** which later separates, leaving a superficial ulceration covered with a shiny mucoid exudate. These ulcers increase rapidly, tracking over the mouth and fauces, and from their superficial character and shiny surface gain the well-merited name of **snail track ulcers.** These ulcers and the congestion naturally give rise to some local discomfort, and so the patient at this stage frequently comes under observation complaining of "sore throat."

In situations where the skin and mucosa meet, and the epithelium of both is liable to be sodden, it frequently heaps up and remains as white opaque masses (**mucous tubercles**). On the skin, hypertrophy of the papillæ and the formation of warty excrescent masses of granulation tissue covered with white sodden epithelium are known as **condylomata.** These occur in moist regions of the body, especially on the scrotum, perinæum, axilla, around the anus, vulva and lips, and usually in persons of uncleanly habits. Not infrequently anal condylomata are mistaken for piles by the patient, but a careful examination will clear up this fallacy easily.

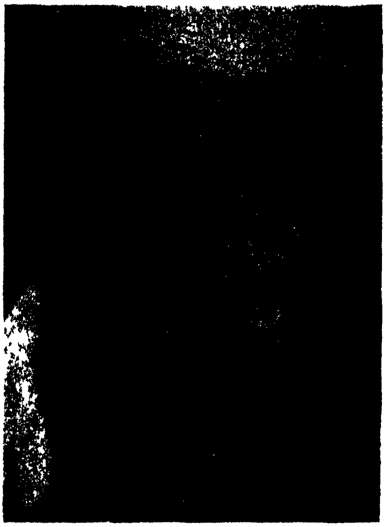


FIG. 43. Gummatous ulcers of leg.

Treatment of this condition is most satisfactory, and consists locally in the parts being regularly cleansed and kept dry with a powder of calomel and starch.

The *lymph nodes* are often slightly enlarged throughout the body, presenting india-rubbery, discrete and painless nodules under the skin, which are more marked in cases of severe infection. In this relation it should be noted that chronic enlargement of the epitrochlear nodes in the arm is very suggestive of syphilitic disease, in the absence of any primary source of infection on the forearm and hand.

Transient inflammatory œdema may occur in any tissue as the result of the immediate reaction to the deposit of a group of spirochætes, and cause fleeting attacks of pain; these are common in the long bones (osteoscopic pains), meninges (headaches), peripheral nerves (transient neuralgia and rarely paresis of muscles) and joints, where a thickening of the synovial membrane, with or without demonstrable effusion into the joint cavity, and frequently symmetrical, often may recur at regular intervals (intermittent hydrops articuli).

Iritis is a rare but serious complication of this stage of the disease, as it usually leaves permanent trouble from adhesions (synechiæ) between the iris and lens or cornea, which hamper the dilatation of the pupil and cause it to be irregular in shape. Moreover, there is often some accompanying inflammation of the lens (**cyclitis**), with subsequent opacities. In the acute stage the eye is tender and very intolerant of light (photophobia) and the iris is thickened, dull and moves sluggishly, the pupil remaining small and covered with yellowish nodules consisting of plastic lymph; the cornea is often dimmed and the lens rather milky in appearance. There is a patch of intense inflammation in the area of the corneo-scleral junction, and great pain, especially along the course of the supra-trochlear and supra-orbital nerves. For further details as to differential diagnosis, treatment, etc., see Vol. II., Chapter III.

Fig. 44. Nodular cutaneous syphilide (syphilitic lupus)

In the later secondary period, sometimes called the intermediate stage, more chronic manifestations of the disease are met with, which are probably really gummatous, and so properly belong to the tertiary stage of the condition, from which, however, they differ in sufficient amount to merit separate description.

Three lesions are commonly encountered:—

(1) A thickening of a diffuse papular type localised to the cutis and accompanied by extensive desquamation and pigmentation; this condition is most commonly met with in the palms of the hands and the soles of the feet, but may occur elsewhere. Like all later secondary and tertiary lesions, it tends to be symmetrical. The condition is known as **syphilitic psoriasis**, but can be diagnosed readily from true psoriasis by its distribution, being on the flexor surfaces of the limbs and palms and soles.

(2) In the skin fairly extensive shallow, spreading ulceration is frequently seen, presenting an appearance not unlike true lupus, but differentiated from it by the more rapid spread, and pigmentation of the central scarred area; this condition is known as ***syphilitic lupus, nodular cutaneous*** or ***tubercular syphilide.***

(3) Another lesion consists in a more chronic ulcerative condition, with piling up of scabs over the floor of the ulcer, so that the whole appearance is suggestive of a limpet shell lying on the skin; this condition is frequently multiple and known as **rupia.**

The tunica intima of the smaller blood vessels frequently proliferates and leads to obliteration of the smaller vessels (*endarteritis obliterans*), with consequent malnutrition of the parts supplied, a serious matter where only end arteries exist; hence lesions of the central nervous system may occur, manifested by transient (and occasionally recurrent) mono- or hemiplegia,

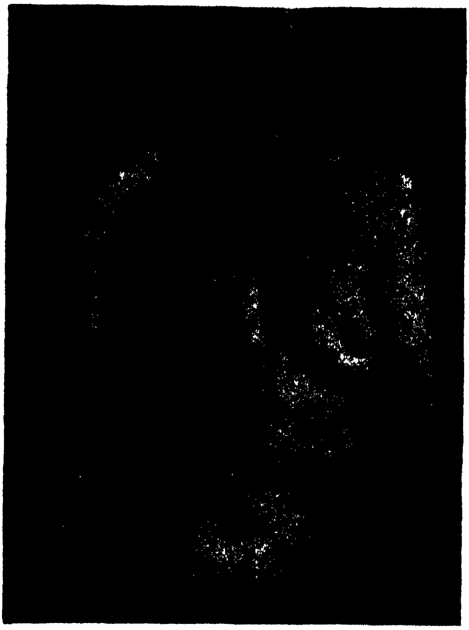


FIG. 45. Extensive rupia.

or paresis of one cranial nerve; in the eye a choroidoretinitis is not uncommon.

Bilateral effusions into the larger joints are also common.

(3) The **Tertiary Stage** is varied in its onset, usually appearing in a year to eighteen months after infection in untreated cases, but it may manifest itself at any time during the patient's life and so indicate that a further course of treatment is necessary. This stage is characterised by the appearance in the tissues of masses of granulation tissue which are formed in the process of reaction to the toxins of the Treponema pallidum, wherever it has established itself, and according as this process is localised or generalised throughout the tissue, so is the infiltration with inflammatory products. In those cases where the tissue reaction localises the infection, the resulting spherical inflammatory mass is known as a **gumma**, and in those cases where a diffuse infiltration of the tissues occurs the condition is spoken of as a **gummatous infiltration.**

The *pathology* of the gumma is that the irritation of the spirochæte falling first on the walls of the blood vessels, or lymphatics by which it is disseminated, causes inflammatory changes in these walls, with proliferation of the cells of the tunica intima of the smaller vessels, and an infiltration of the tunica media with small lymphocytes, plasma cells and fibroblasts. This leads to obliteration of the vessel lumen and thrombosis, with the result that the nutrition of the surrounding tissues is impaired, thus rendering it either (1) necrotic, when a mass of dead tissue results, with the formation of caseous material surrounded by an area of lymphocytic infiltration and fibrosis, *i.e.*, a gumma; or (2) a favourable pabulum for the spread of the infection, as its powers of resistance are much lowered, and the infection can thus spread extensively and involve large areas irrespective of the types of tissue, *i.e.*, a gummatous infiltration results.

This may involve many varieties of tissue (muscle, bone, etc.) in the one

Fig. 46. Gumma of sternum.

area—a point helpful in differentiating it from a new growth such as sarcoma, which tends to remain localised to one tissue.

These conditions are succeeded ultimately by fibrosis and scarring, which in the case of the diffuse infiltration gives to the tissues when seen in section a

Fig. 47. Gummatous ulcer of foot.

peculiar and characteristic appearance, suggesting that their structure is faintly seen through a sheet of ground glass. In those cases where the stress of the infection falls on the lymphatic vessels extensive thickening and lymphatic œdema (see Chapter XI., p. 308) may result.

Microscopically, the infiltrated area is at first sight very suggestive of that seen in tuberculosis, but a closer examination reveals the fact that the giant cells are more scanty, the endothelioid cells absent, and the lymphocytes and fibroblasts present in greater numbers. It is the exception rather than the rule to find the Treponema pallidum in a section, though this organism is present in every gumma in greater or smaller numbers.

It may be difficult sometimes to determine whether a given specimen of caseous material is gummatous or tuberculous in origin, and the following points may be found helpful in determining this :—

(*a*) The caseous material in a gumma is usually yellowish in colour, whereas in tuberculosis it is greyish white.

(*b*) The tuberculous caseous material tends to liquefy much earlier than the gummatous.

(*c*) An examination of the tissue around the caseous area always will reveal the presence of greyish white tubercles visible to the naked eye in tuberculous cases ; these are never seen around gummata, where there is usually denser fibrosis than seen around a tuberculous lesion.

It must be borne in mind that, as in tuberculosis, the caseous material in the gumma may either : (1) be absorbed and carried away by the blood stream (a process in this case much assisted by the administration of potassium iodide, which forms a soluble iodine albuminate with the dead protein), when a fibrous scar results ; (2) break down and form a semi-solid, fluctuant mass, which if situated near the surface will discharge through the necrosed epithelium and give rise to a gummatous ulcer (Chapter VII., p. 150) ; or (3) become encysted and, the fluid being absorbed, become infiltrated with calcium salts, a process not infrequently met with in the liver.

Clinically, the signs in the third stage of syphilis will differ widely, according as the gummatous condition is localised or diffuse.

The **localised gumma** presents a rounded thickening in the tissues, the edges of which fade into the surrounding tissue, from which they cannot be differentiated clearly, a characteristic of all inflammatory lesions as against new growths. The onset is usually gradual and the history indefinite, the mass tending to enlarge slowly, and after some weeks, or even months, to soften at the centre as necrosis occurs, a process indicated by the development of fluctuation.

If the gumma is near an epithelial surface, the mass tends to break down, the skin giving way to form a typical *gummatous ulcer*, with its circular shape, steep-cut edges, and its centre occupied for the first ten days or so by the mass of necrotic caseous material (wash-leather slough), which as it separates leaves the deep ulcer and reveals the bright red, firm granulations on the floor so typical of this condition. Inasmuch as the gummata are frequently multiple, several may coalesce, in which case the resulting ulcer presents a crenated margin from the fusion of the several circular masses. These ulcers tend to heal, when they leave a thin white parchment-like scar, but frequently break out again and become secondarily infected in time, thus losing their characteristic appearance, and showing

FIG. 48. Gummatous ulcer.

pigmentation in the parchment-like scar which results when healing is ultimately obtained.

Such ulcers are frequently associated with varicose eczema, but the presence of healthy red granulations on the floor of any chronic ulcer, as will be pointed out (Chapter VII., p. 151), should at once arouse a shrewd suspicion that a gummatous element exists as the cause. Gummata are frequently met with in the skin, subcutaneous tissue, liver, muscles and skull bones.

In the **diffuse gummatous infiltration** there is a generalised thickening of the structures, not localised to any one variety of tissue but, as already pointed out (p. 117), involving all the structures in the area indiscriminately, a point of great value in diagnosing the condition from sarcoma, which usually infiltrates the tissue in which it originates fairly widely before spreading into surrounding structures. The condition is painless unless occurring in dense tissue, such as bone, where nerves become pressed on and great pain may result, and is aggravated by heat or any other cause of congestion in the area.

Breaking down and caseation are rare in this type of the disease. The diffuse infiltration commonly affects the bones, meninges, testes, synovial cavities, and more rarely cellular tissues and muscles.

(4) **Parasyphilitic lesions**, which occur as late sequelæ of the infection, fall mainly into two great groups:—

(*a*) *Cardio-vascular*, due to degenerative changes in the walls of the blood vessels; those of interest to the surgeon, such as aneurysm, are dealt with in their appropriate places.

(*b*) *Nervous* lesions of the brain and spinal column, such as general paralysis and tabes dorsalis (locomotor ataxy), which come more properly under the physician, and are therefore only dealt with in this book under the appropriate headings, in so far as certain complications of tabes, such as gastric and bladder crises (Vol. II., Chapters XV. and XX.), perforating ulcers (Chapter IX., p. 248), and Charcot's joints (Chapter XIX.), are of interest to the surgeon in differential diagnosis.

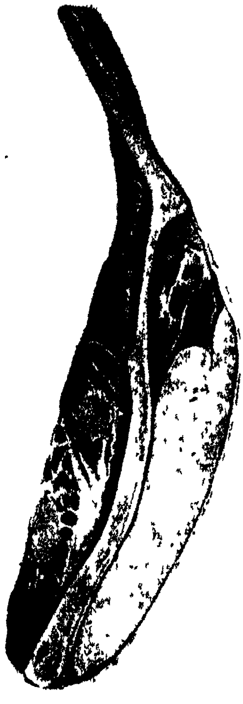


FIG. 49. Gummata and gummatous infiltration of the scapula and muscles. Note hazy appearance of structure in the affected infraspinatus.

This is perhaps an appropriate place to draw attention to the salient features to be observed in a case of **tabes**, and to bring to the notice of every student the absolute necessity of making an examination to eliminate this disease in all cases of abdominal and urinary disorders, joint affections, perforating ulcers, so-called rheumatism, and other conditions too numerous to mention, where the failure to recognise the presence of tabes is too often a pitfall for the unwary.

The tabetic patient usually has an unsteady, high-stepping and stamping gait, and the forehead is seen to have a wrinkled and worried expression, though the patient is quite cheerful, this condition being due to the contraction of the frontalis and corrugator supercilii muscles, which compensates for the ptosis of the upper lid and keeps the eyes open. Examination shows the absence of knee and other tendon reflexes, and the presence of the Argyll

Robertson pupil, which reacts to accommodation, but not to light, anæsthesia of the skin and loss of bone sense. It must, however, not be thought that absence of the signs of tabes is any indication that a patient has never had syphilis.

The *prognosis* of syphilis has been somewhat improved of late, owing mainly to our ability to recognise the Treponema pallidum in the primary lesion early, so that one is able to start treatment much earlier in the course of the disease; and partly owing to the discovery of the organic arsenical compounds, by the use of which the disease can be more rapidly and thoroughly mastered than was the case when mercury alone was employed.

It is still shown at intervals, however, that cure even by these methods is by no means certain, and a patient once infected should be kept regularly under observation, and the Wassermann reaction taken annually for several years; for relapses to a positive Wassermann reaction after a long period of apparent cure are known to be frequent, and depend on the escape into the blood stream of organisms whose previous encapsulation by fibrous tissue has led to their escape from the effects of the previous drug treatment.

This makes the ultimate prognosis grave, and even under the most favourable conditions it is doubtful if a permanent cure can be effected, though the disease now certainly can be controlled by systematically repeated courses of treatment; undoubtedly the earlier in the incubation period the disease is diagnosed and treatment instituted, the better the result, as is shown by the local inoculation of 25 per cent. calomel ointment within twenty-four hours of infection aborting the disease; the figures produced by Gibbard and Harrison show that whereas the cures in cases treated before induration of the primary chancre has occurred amount to 99 per cent., in those cases left till after induration has manifested itself the cures amount to only 60 per cent. of the cases treated.

The *diagnosis* of the condition in its various forms will be dealt with under the suitable headings.

The **treatment** falls naturally into general measures to combat the effects of the organisms in the blood stream and tissues, and local treatment of such lesions as require it.

(A) *General treatment* should be started promptly as soon as the disease is diagnosed, and must be carried out thoroughly to be efficient. In the past many drugs have been used in the treatment of syphilis, but of these only mercury is of value, and before the discovery of suitable organic arsenical compounds this was the drug in use in the treatment of the disease; moreover, it is still a valuable adjunct to the arsenical treatment, being more slowly excreted from the body and thus more prolonged in its action than the arsenic, which, however, has greater penetrating power.

Following the discovery of the protozoal origin of syphilis, and knowing the effect of *arsenical treatment* in allied diseases such as trypanosomiasis, Ehrlich, after a series of none too successful trials with various organic arsenical compounds, introduced a substance, dioxy-diamido-arseno-benzol (arsphenamine, or "606"), which has proved of the utmost value in the treatment of the disease. Because of the inconvenience of administration, this drug is not much used in this country; its place has been taken by various substitutes and successors of a like nature, such as neoarsphenamine, stabilarsan (glucoside in solution), sulpharsphenamine, and mapharside (arsenoxide, dosage 0·04 to 0·06 gm.).

These drugs, which are readily soluble powders, are given intravenously or intramuscularly in distilled water in doses of 0·3 to 0·75 gram ; they are thus rapid in action, but somewhat quickly excreted, and so transient in effect ; they need to be given repeatedly or supplemented by mercurial or bismuth injections. Attempts have been made to give the older arsenical compounds intramuscularly, but extensive sloughing is usually the result, and for this reason care must be taken that no drug escapes into the tissues during the intravenous administration, or sloughing, with the formation of very callous ulcers, is almost certain to follow.

Inquiry shows that the routine treatment by this method differs very extensively in the various venereal clinics, and it is only possible roughly to indicate the lines of a routine course which should clear up the infection, blood tests being taken at regular intervals to control the reaction.

The following course of treatment used at St. Thomas's Hospital has been proved, especially in acute syphilis, to give satisfactory results with a minimum of toxic effects.

Total weeks	Week	Mapharside	Bismuth.	
8	1	0·06 gm.	0·2 gm.	Blood Test.
		0·06 gm.	0·2 gm.	
	2	0·06 gm.	0·2 gm.	
		0·06 gm.	0·2 gm.	
	3	0·06 gm.	0·2 gm.	
		0·06 gm.	0·2 gm.	
	4	0·06 gm.	0·4 gm.	
	5	0·06 gm.	0·4 gm.	
	6	0·06 gm.	0·4 gm.	Mist. Hydrarg. Iod. by the mouth.
	7	0·06 gm.	—	Mist. Hydrarg. Iod. by the mouth.
	8	0·06 gm.	—	Mist. Hydrarg. Iod. by the mouth.
6	9 to 14	— —	0·2 gm. *twice-weekly*	
10	15 to 24	0·06 gm. weekly	—	Blood Test. Mist. Hydrarg. Iod. first three weeks.
8	25 to 32	— —	0·4 gm. weekly.	Spinal-fluid test ?
10	33 to 42	0·06 gm. weekly.	—	Blood Test. Mist. Hydrarg. Iod. first 3 weeks.
10	43 to 52	—	0·4 gm. weekly.	
10	53 to 62	0·06 gm. weekly.	—	Blood Test. Mist. Hydrarg. Iod. first 3 weeks.

Total weeks.	Week.	Mapharside.	Bismuth.	
10	63 to 72	—	0·4 gm. weekly.	
10	73 to 82	0·06 gm. weekly.	—	Blood Test. Mist. Hydrarg. Iod. first 3 weeks.
10	83 to 92	—	0·4 gm. weekly.	
	93	—	—	Blood Test. Spinal-fluid test if possible.

If negative, a blood-test should be performed every three months for twelve months, and thereafter every six months.

If positive, Bismuth and Pot. Iod. (or Hydrarg. Iod.) are given for an indefinite period.

A minimum of twelve months' continuous treatment *after* the patient is clinically and serologically negative is essential.

Mapharside may be replaced in the above scheme by the less efficient and more toxic neoarsphenamines.

It must be remembered that arsenic cannot be tolerated by some persons, in whom a violent exfoliative dermatitis is caused by very small doses, and, again, patients suffering from renal and hepatic disease tolerate the drug badly, and are liable easily to develop toxic symptoms, such as jaundice, dermatitis, neuritis, gastro-intestinal symptoms, or in the case of renal patients acute nephritis going on to uræmia and death. In rare cases a monoplegia or paraplegia may supervene. In such cases arsenic must be given very cautiously, or better, treatment by bismuth mercurial injections substituted.

Bismuth salts (usually the oxychloride) are now being extensively used as a substitute for mercury in weekly doses of 0·2 gram injected deeply into subcutaneous tissues, and certainly they are less toxic and are capable of penetrating the central nervous system, while their injection is practically painless, but there are cases not infrequently which do not yield to this treatment and then *mercury* must be employed.

Mercury may be best administered by the *intra-muscular injection*, usually into the buttock midway between the great trochanter and iliac crest, of a fine emulsion of either metallic mercury or calomel with sterilised lanoline. Such injection is painful and the effects continue for some days. This emulsion, which is solid at ordinary temperature, needs heating by immersion of the bottle in which it is contained in hot water, before injection, which operation should be carried out with all surgical precautions, the needles being for greater safety boiled on oil. The creams thus constituted are known as Lambkin's No. 1 (mercury) and No. 2 (calomel), the prescriptions being:—

No. 1. ℞ Hydrargyri . . . . . . ℥ss
Adipis Lanæ . . . . . . ℥ij
Paraffin liq. (carbolised 2 per cent.) ad ℥v,

this giving a solution ♏x of which contains gr. i of mercury.

No. 2.	℞ Calomel	ʒij
	Adipis Lanæ	℥ij
	Paraffin liq. (carbolised 2 per cent.) ad	℥v,

this giving a solution ♏x of which contains gr. $\frac{1}{2}$ of calomel.

The best course of treatment by this method is to inject daily for three days No. 2 cream in doses of ♏vij, *i.e.*, one-third of a grain of calomel daily, followed by six weekly injections of No. 1 cream in ♏x doses. A rest of one month is then given, and the No. 1 cream injections repeated. The whole course is repeated at the end of six months; the Wassermann reaction is then taken, and, if negative, compared with that obtained at the end of another six months' rest, when a further No. 1 course is advisable, and again at the end of another year's rest. This course may be replaced partially by the substitution of arsenical injections.

Other methods of mercurial medication are:—

(1) *By the mouth*, the soluble salts being used, such as liq. hydrarg. perchlor., which is given in ʒi doses, or in the form of pills of mercury usually mixed with chalk, or opium, to counteract the purgative action, the favourite being Hutchinson's pill, the prescription of which is:—

℞ Hydrarg. c̄ Cretæ	gr. i
Pulv. Ipecac. Co.	gr. i,

one or two of these pills being given twice a day, and each containing one-fourth of its weight of mercury.

(2) *Inunction* of the drug in the form of the official Ung. hydrarg. into the soft skin of the abdomen, axillæ and thighs is much advocated by some authorities: ʒi of ointment (a piece roughly the size of a hazel nut) is well rubbed in daily for six weeks, the course being repeated in six months. This method brings the patient rapidly under the influence of mercury, but is liable to cause dermatitis. It is well to bear in mind that pigmentation of the skin from the formation of sulphide often occurs, and the person rubbing in the drugs should be cautioned to wear rubber gloves during the process.

(3) Treatment by *mercury vapour* baths was at one time much in vogue, but is most unsatisfactory both as regards absorption and the tendency to dermatitis, and is not to be recommended.

A word of caution is necessary in regard to the onset of various signs which may indicate that over-dosage of mercury has been given; the resulting condition, known as *mercurialism*, is indicated by the presence of a metallic taste in the mouth, which on examination is found to present a red, inflamed and swollen mucosa, especially around the teeth, while in severe cases necrosis of the jaw may be present and teeth fall out, or sequestra be seen. The breath is fœtid, and there is frequently diarrhœa and severe abdominal colic. Erythematous and eczematous skin rashes may be present.

In the late secondary and tertiary stages of syphilis the absorption of the caseous material and the consequent assistance to the penetration of the anti-syphilitic drugs are much aided by the administration of *iodide of potassium* which greatly facilitates the absorption and removal of the proteins in dead tissues. This drug to be of full value needs to be given in steadily increasing doses; it is then stopped for a period, when the maximum is reached, the course being repeated later. So given, absorption of the dead material among the granulations, and indirectly the disappearance of these themselves as the blood supply increases in the area, is very rapid and complete, whereas if only a small dose be administered over long periods, the cure of the lesion may be neither complete nor permanent.

It cannot be impressed too strongly on the student that potassium iodide has no curative effect upon syphilis *per se*, but only aids in the removal of dead albuminous material such as is met with in gummatous lesions, and that, additional treatment by arsenic, and bismuth or mercury is essential in these cases.

The course of iodide treatment is, on general lines, as follows: commencing with a dose of grs. x t.d.s. well diluted, this is increased weekly by grs. v t.d.s. until the patient is taking grs. xxx–l t.d.s., when this dose is maintained for three weeks, and the course then ceases, to be repeated in six weeks' time.

As iodides are very unpleasant to taste, dilution and removal of the salt taste are best accomplished by giving the drug in small bulk and directing that a half tumbler of water be drunk immediately after. Should signs of "iodism," such as rashes, lachrymation, indigestion or vomiting, manifest themselves, these can usually be cured by either doubling the dose of iodide or adding liquor arsenicalis ℳiv to each dose of the mixture.

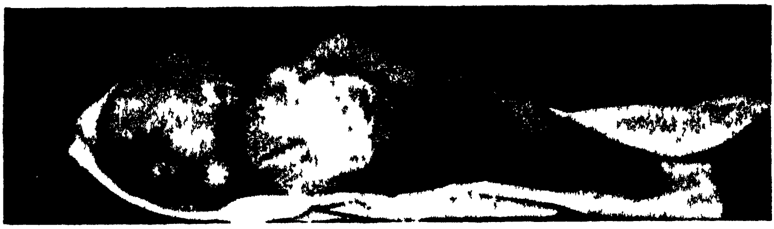


FIG. 50. Congenital syphilitic infant. Note emaciation, enlarged abdomen, and epiphysitis.

(B) *Local Treatment*. In the primary stage the sore should be removed if possible, *i.e.*, circumcision if it is on the prepuce, as by so doing the chief source, at that stage of the disease, of spirochætal spread is eliminated, and a focus of subsequent fibrosis, in which spirochætes are known to be encapsuled and so rendered difficult of destruction by drugs, is removed. Should this be inconvenient owing to the situation of the sore, all that is needed is to keep the parts clean and impress on the patient the infectious nature of the discharge.

In the secondary stage cutaneous lesions call for little treatment beyond protection, while those of the mucous membranes only need cleansing, and for this purpose a gargle of weak carbolic (1 in 200) or potassium chlorate are quite efficacious. Joints may be treated by Scott's dressings, and epididymal infection, should it occur, by support to the scrotum.

Nervous lesions call for no local treatment, and, like secondary manifestations, emphasise the need for prompt and general antisyphilitic treatment, which from a curative standpoint is alone of value. Condylomata if present, as already stated, should be kept dry and clean and dusted with calomel and starch powder.

Gummata need no local treatment unless ulceration has occurred, in which case steps should be taken to assist the separation of the slough by means of dressings of lotio sodæ chlorinatæ, and when this has been accomplished, healing may be aided by the use of a dressing of lotio nigra. The administration of potassium iodide combined with antisyphilitic drugs is a valuable adjunct. No gumma ever should be incised or excised, as prompt general treatment is always followed by reabsorption of fluid and cure.

Syphilis in relation to Marriage. A patient who gives a persistently negative Wassermann reaction for six consecutive three months after a full course as advocated can be regarded as fit to marry, though it is often advisable to administer a short course of treatment for a few weeks immediately preceding the ceremony. Should the disease be transmitted it is more likely to be manifested in the earlier offspring than in either parent.

CONGENITAL SYPHILIS

As already stated, syphilis is a disease capable of being transmitted by either parent to their offspring, and in this case the pregnancy very frequently terminates prematurely, following the death and often maceration of the fœtus in utero. If this is so, the tissues of the dead and decomposing fœtus, especially the liver, lungs and spleen, are found to be swarming with spirochætes. Miscarriage of a dead fœtus may occur in several successive pregnancies, but becoming gradually later, until a premature or even full-term living child is born; this may show signs of the disease at birth, but is usually apparently healthy for the first three or six weeks, and then begins to waste and show signs of the syphilitic taint.

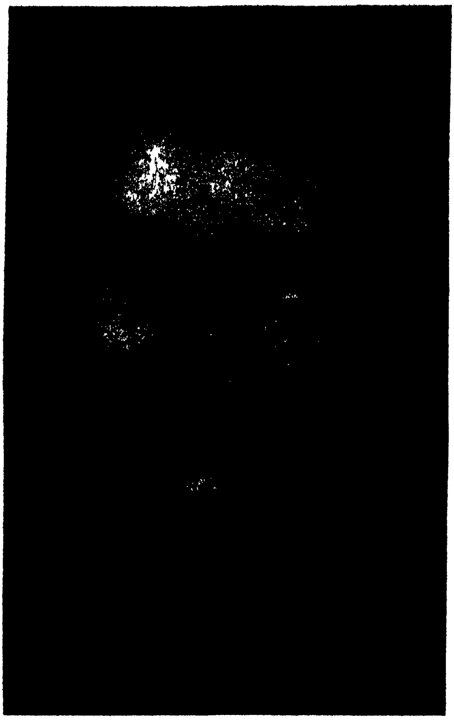


FIG. 51. Congenital syphilis. Note rhagades around the mouth and depressed nasal bridge.

In many such cases infection of the ovum doubtless occurs from the infected paternal spermatozoon during fertilisation, but it may occur from the maternal circulation *via* the placenta at any period of gestation, or even be acquired from the maternal passages during birth; though in this last case it is to be expected that a primary sore would be seen on the child after birth, a condition never met with, and suggesting that the baby is either previously infected or protected by the vernix caseosa.

The mother of a syphilitic baby may not show any visible signs of the disease, and yet can suckle the child without fear of infection, whereas a healthy wet-nurse always acquires the infection and shows a primary sore on the nipple; this fact was observed by Colles early in the nineteenth century, and he expressed the opinion now known as "Colles' Law," that the parents of syphilitic children were immune from acquiring the disease from their offspring, which as they are already infected with the disease is a correct statement of fact.

What is much more important is that such children are infectious to healthy persons and children, and therefore need early and thorough treatment, although if left untreated they later cease to be infectious in the vast majority of cases (usually after puberty). Although in a few instances it seems possible that the disease may have been transmitted to the third generation, well-authenticated cases of this are very rare, especially in view of the practical impossibility of eliminating the chance of acquired infection.

It is sometimes stated that congenital syphilitics cannot acquire the disease de novo, but this can be shown in some cases to be inaccurate, and although the acquisition of syphilis is not common in such cases, it undoubtedly does occur, especially if the child has been efficiently treated in early life.

Clinically, the child is usually healthy for the first month or six weeks after birth, and then begins to become thin and wasted, vomits its food, is fretful, and shows a wrinkled dull earthy skin, with the pinched and wizened face of an old man or monkey. The child is anæmic and shows marked enlargement of the liver and spleen. There is often desquamation of the skin of the palms and soles (a condition akin to syphilitic psoriasis), and a dull coppery rash about the nates and groins, which if the parts are allowed to remain moist and unclean become infected and present the features of *condylomata*, which lesions are also met with around the angles of the mouth; on healing, these leave a series of *radiating scars*, which are very characteristic and helpful in diagnosing the condition in later life. Rarely, large areas of epithelium become raised up, the bullæ being filled with sanious serum, and often becoming infected, the child's body being a mass of stinking bullæ and necrosing epithelium. This condition, known as *syphilitic pemphigus*, is usually rapidly fatal.

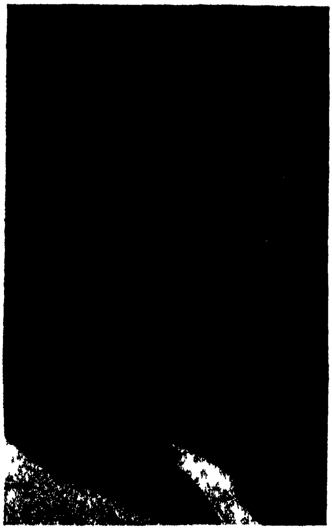


FIG. 52. Congenital syphilitic facies.

Catarrhal infection of the mucous membranes is common, particularly in the nasal fossæ, where the resulting obstruction to breathing gives rise to a characteristic nasal discharge and "*snuffles*"; the condition if untreated spreads to the nasal and ethmoid bones, which necrose, and so by their non-development cause the sunken bridge of the nose, which is such a damning stigma of the disease in later life.

Other manifestations are bronchial and pulmonary in character, and another and little recognised one is an otitis media, which frequently goes on to mastoid disease (Vol. II., Chapter VII.). Gastro-intestinal symptoms are not uncommon.

Many of these children die within the first six months of birth from marasmus (wasting) and debility, but should they survive they usually suffer from further manifestations of the disease. In this respect it must be borne in mind that the early recognition and systematic treatment of the disease in early infancy has not only greatly reduced the mortality from the condition, but has also largely prevented the development of the subsequent tertiary manifestations about to be described, with the result that they are fortunately rarely met with in any degree of severity in these days, and must therefore only be expected and sought for in their minor degrees.

Bone changes manifest themselves early, especially in the epiphyses and membrane bones of the skull, which become the seat of either (i.) a *diffuse gummatous* infiltration, when they become thickened and spongy, and the skull presents four hard bosses in the parietal and frontal regions (*Parrot's nodes*), which give it a typical hot-cross-bun appearance, a condition seen as early as the third or sixth month ; (ii.) *localised gummata*, usually multiple, may occur and lead to absorption of large areas of bone, the skull being absorbed and replaced by papery scar tissue—a condition not nearly so common as Parrot's nodes, and known as *cranio-tabes.*

Later *gummatous infections of the epiphyses* of long bones, leading to partial dislocation and subsequent impairment of growth of the limb, not infrequently occur, and should be suspected in any case where a baby's limb is held motionless and apparently paralysed, and on examination shows thickening around the epiphyseal lines (see Chapter XVIII.).

Diffuse osteitis of the shafts of the long bones, leading to distortion, *i.e.*, sabre tibia, etc., are common in older children, and may be localised (nodes) or diffuse ; these conditions are also dealt with fully in Chapter XVIII.

The *joints*, especially about puberty, are frequently the seat of a chronic synovitis with effusion, but very little synovial thickening ; the larger joints are commonly affected, the condition being symmetrical, and known as *Clutton's joints* (see Chapters XIX., p. 605, and XX.).

The *teeth* are frequently stunted and deformed as the result of interference with the growth of the tooth germ, the temporary or milk teeth being affected and often appearing very early and decaying rapidly. The condition characteristically seen is that all the *permanent teeth* are "peg-top" in type, *i.e.*, broader at the root and tapering to the crown, the incisors presenting a deep and broad central notch in the free margin, and the molars and pre-molars being stunted with pointed cusps and often ill developed : these are known as *Hutchinson's teeth.*

In addition to this the permanent teeth are often set widely apart, but are otherwise healthy, and as it is unusual for a congenital syphilitic to acquire the disease de novo, it has long been regarded as a sign of luck for an individual to be "gap-toothed."

The Ear. Infection of the internal ear with resultant sclerosis, or of the middle ear with necrosis of ossicles, leads to otitis and subsequent deafness. Many of these children are therefore deaf.

The eye is not often affected before puberty, but about that period it is not uncommon to meet with an *interstitial keratitis*, which first appears in one eye, but later becomes symmetrical, and always causes impairment of vision from the scarring left in the cornea. In the acute stage there is pain and photophobia; the cornea appears hazy, and looks like ground glass. The trouble not infrequently spreads to the lens and iris, and serious trouble may result (see Vol. II., Chapter VI.).

Occasionally *choroiditis* and *optic atrophy* are met with in congenital syphilis.

Epididymo-orchitis, painless and symmetrical, is occasionally seen in infants, and is always followed by testicular atrophy with subsequent lack of sexual development and sterility.

Parasyphilitic lesions may manifest themselves rarely at an early age, both tabes dorsalis and general paralysis occurring in infants, while arterial degeneration, with consequent renal disease and high blood pressure, is not very uncommon.

As in the acquired condition, the Wassermann reaction, though constantly positive in the active stages of the disease, is uncertain in the later, and may be negative in cases which clinically present all the signs of tertiary or parasyphilitic lesions, with signs of the stigmata of the congenital type of the disease.

The *differential diagnosis* of the condition may present difficulties, especially in those cases where no suspicion has fallen on the parents, but the gradual wasting of the baby, born healthy, within the first few weeks of life, always should lead to a suspicion of congenital syphilis, although it should be borne in mind that such conditions as congenital pyloric stenosis and gastro-intestinal and feeding disturbances will have similar results ; however in these cases there are none of the other signs of syphilis, such as rashes or bone lesions. Later in the first year of life rickets, with its thick head and pot belly, may cause difficulty, but here the child is fat, and although the spleen is enlarged, the liver is seldom markedly palpable. Achondroplasia is likely to cause more trouble than most diseases in the first few years of life, but the child is quite healthy, and the typical appearance of the hands with their tapering and diverging fingers is characteristic of the condition. Scurvy infantilis and traumatic lesions of the regions of the joints may give rise to confusion with gummatous epiphysitis, but the history and an X-ray film will clear up the diagnosis. Tuberculous lesions, especially of the bones, peritoneum and lungs, are always a source of difficulty, and are indeed frequently wrongly diagnosed until a Wassermann reaction clears up the doubt.

These various conditions are more fully dealt with under their appropriate headings.

Treatment, to be effective, must be on the same thorough lines as already laid down for the adult, and must be started so soon as the disease is diagnosed, when marked improvement is early manifested and steadily maintained. The dosage given is, of course, considerably less than in the case of an adult.

Mercury is best administered either in the form of grey powder (hydrarg. c̄ creta), gr. ½ or i t.d.s., or by daily inunction, the child being kept wrapped in flannel. Arsenical compounds must be given in suitably reduced doses.

It is essential to remember that *both the parents must be treated* in order to save infection in future offspring, and that *on no account must the child be given to a foster-mother to nurse,* so that should the mother be unable to nurse it, the baby must be bottle-fed.

Local lesions must be treated in the same manner as in the acquired form of the disease.

(c) LYMPHOGRANULOMA INGUINALE

Lymphogranuloma inguinale is a disease following infected coitus, especially in Central, Northern and Eastern Europe ; several cases have been reported in this country of recent years, mostly among the sailor population and around seaports and docks.

The primary sore is a small papule and often escapes notice, occurring sometimes in the urethra, from which a sterile milky discharge exudes ; usually this appears about two weeks after infection, but may be noticed from three days to three weeks ; both the lesion and discharge are painless and transitory.

Generally in about three weeks, but perhaps as long as six weeks after infection, the inguinal lymph nodes on one or both sides become enlarged, matted and tender, and the overlying skin is œdematous, adherent and shows dusky discoloration; suppuration occurs and the glands break down, discharging thick, creamy, white pus, while the resulting sinus heals in most cases. The pus-like smears from the primary lesion are sterile. The diagnosis may be confirmed by Frei's test.

Treatment consists in rest and keeping the sore clean by applying a mild antiseptic dressing. Sulphanilamide drugs must be administered and produce not only rapid healing of early lesions, but considerable amelioration of rectal strictures and kraurosis. The patient should rest in bed if glands develop, and, should suppuration occur, aspiration or incision should be resorted to and the wound dressed with sterile dry dressings. In most cases healing occurs rapidly. No specific organism has been found, the Wassermann reaction is negative, and arsenical compounds have no apparent effect either in human beings, or on the disease which reproduces itself true to type in monkeys, and causes a characteristic encephalitis when inoculated into the brains of mice. The disease is met with in women, in whom *esthiomène* (kraurosis vulvæ) seems a closely allied condition, and where rectal stricture is a common after-effect, as it may be rarely in males.

(*d*) YAWS

Yaws (Frambœsia tropica) is a disease seldom seen in this country but

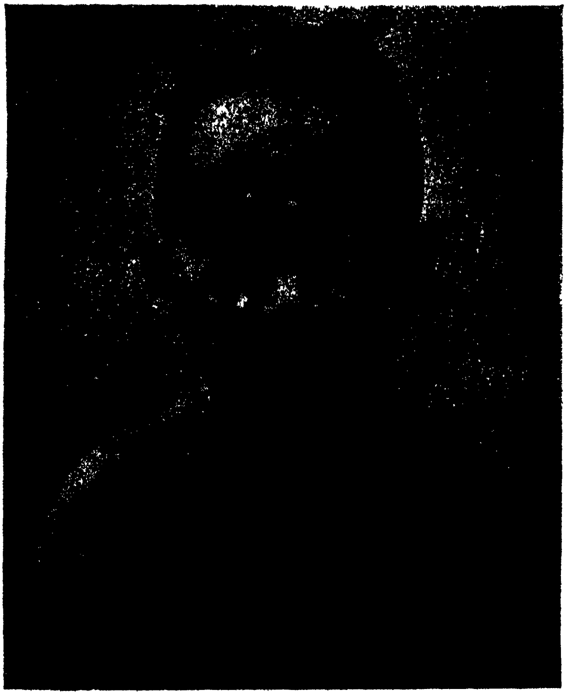


FIG. 53. Secondary yaws.

common in various parts of the tropics, such as the Malay Archipelago and West Indies. It is very closely allied to syphilis, and, like it, due to a protozoon micro-organism (Spirochæta pertenuis), which is transmitted by direct contagion from the sores, or by means of soiled clothing, flies, etc.

The *primary lesion* is often found on the face, and its appearance is accompanied by great pain and some constitutional disturbance; it is usually single and rapidly ulcerates. *Secondary granulomatous nodules* appear in the tissues around and elsewhere in the body; these ulcerate rapidly and the patient soon presents a horrible appearance, being covered by masses of granulating ulcerative sores. These may heal and lead to extensive scarring or spread deeply and involve other organs, leading to sinus formation and deformity.

Treatment. This consists in administration of salvarsan or its derivatives, when the disease rapidly disappears; often one injection suffices to clear up the most extensive and old-standing case. Unlike syphilis, mercury and iodides have little or no influence on the progress of the disease.

Rarer conditions, such as *granular pharyngitis* and *granuloma of the pudenda,* ulcerative conditions of the mouth or pharynx and genitalia respectively, are met with in the West Indies and other tropical countries, are closely allied to yaws, and like that disease yield readily to salvarsan injections.

(*e*) DELHI BOIL

This condition of chronic ulceration of the skin in exposed areas, such as the face or dorsum of the hand, occurs over South-East Europe, Asia Minor, India and N. Africa, and is known by the name of Aleppo boil, Baghdad sore, Oriental sore, etc.

Infection occurs through abrasions of the skin and is possibly fly-borne, the parasite being a clear ovoid cell containing two nuclei, the macro- and micro-nucleus, which stain deeply, especially the latter, and are identical with the Leishman-Donovan bodies seen in kala azar. If a drop of water is placed on the living organisms, they emerge from their covering and become actively motile, and can be seen to possess flagellæ.

FIG. 54. Oriental sore (Delhi boil).

Clinically, the condition starts as an indurated dusky papule, and there may often be several such lesions; these rapidly break down and coalesce, forming a chronic ulcer with an indurated margin and covered with a mass of crusted scabs, the removal of which reveals fairly exuberant pale granulation tissue. If left untreated, the condition heals in time, usually taking from one to two years.

The *diagnosis* is easy if the parasites are looked for, and the crusts on the ulcer are very characteristic.

Treatment. Excision is the only satisfactory treatment, though dressings of 5 per cent. solutions of copper sulphate or tartar emetic seem to hasten healing, as also do pressure continuously applied by strapping, and exposure to X-rays.

(*f*) ACTINOMYCOSIS AND ALLIED STREPTOTHRIX INFECTIONS

The streptothrices form a group of branched fungi somewhat higher in the vegetable scale than the bacteria, and are characterised by the formation of a dense network of branching filaments (the mycelium) which is Gram-positive, in all the many varieties pathogenic to man, and which present small lateral branches which are diagnostic. In some varieties, such as *streptothrix actinomyces*, a variety commonly met with in cattle, but rarely in man, spore formation is commonly seen, these presenting masses of radially arranged deeply staining chain spores, which are usually known as "clubs." The organisms are difficult to culture, many of them being strict anaerobes.

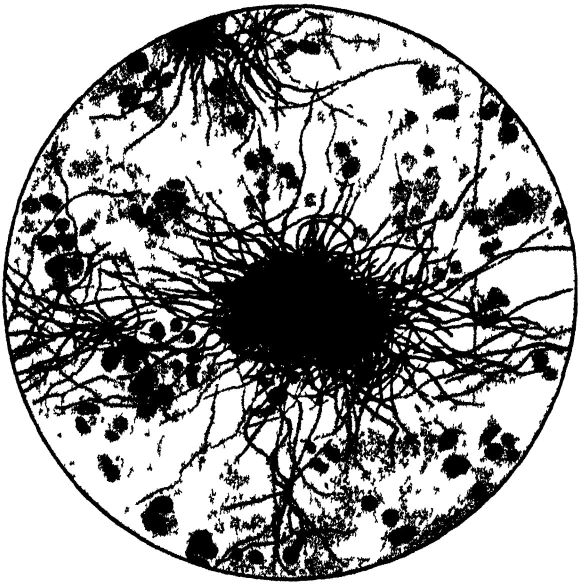


FIG. 55. Streptothrix mycelium in pus (× 500).

Infection is usually thought to occur from the husks of cereals, especially barley, and the disease is often met with in the jaws and face of cattle, and in grooms, farmers, etc., but many persons infected have no history of infection from any such source. The organisms gain admission through any abrasion in the mucosa or skin, or through a carious tooth, and infection may occur in the tongue, mouth and fauces, lungs or intestinal tract; also often in the appendix region, whence it spreads rapidly to surrounding viscera, and by a process of pyæmic infarction infects the liver.

The progress of the disease is very chronic, and if treated early in the mouth and face there is a fair chance of cure, but cases affecting the internal organs are almost always fatal.

Clinically the onset of the disease is insidious, the first sign observed being a subcutaneous or submucous thickening beneath the site of infection; this is usually quite painless, and spreads steadily, its margins fading gradually into the surrounding tissues. Microscopically this is seen to consist of granulation tissue, among which masses of mycelium can be observed. Sooner or later suppuration occurs, and the mass softens and ultimately breaks down, the pus being discharged to the surface by a number of small sinuses all over the area, which is by now fixed to the brawny and infiltrated epithelium.

The discharged pus is characteristic, consisting of a thin sero-pus, among which can be detected sulphur-coloured granules, which on examination are seen to be masses of mycelium; these granules may give some indication as to the type of streptothrix present, being bright yellow and solid in actinomycosis; in man the two common types met with are pale sulphur yellow, one variety being of a soft consistency and the granules larger, whereas the other shows smaller and harder granules.

In all cases the diseased area slowly increases in size and involves surrounding tissues, which are gradually destroyed; in the *abdominal cases* the urinary tract may be involved and granules voided in the urine, while very extensive infiltration of the abdominal parietes, usually with the formation of numerous fæcal fistulæ, occurs sooner or later; so also does involvement of the liver, which presents on section a characteristic honeycombed appearance, rather suggestive of the implantation of a coarse sponge filled with granular pus into its substance.

In *pulmonary cases* the signs are those of consolidation, with some temperature and expectoration, in which examination shows the characteristic granules to be present; such cases are often mistaken for tuberculosis or pulmonary or mediastinal tumours. The pleura and parietes become infected, and empyema and secondary invasion of the liver are not uncommon sequelæ.

In *the cervico-facial type*, hæmorrhage from the invasion of the large vessels may give rise to alarming and sometimes fatal symptoms, while involvement of the facial or other nerves may cause paralysis in the neighbourhood, and the scarring in the lesion always produces severe and obstinate trismus.

The *diagnosis* may present considerable difficulty unless the granules are found, or mycelium is detected in the pus; and in this respect it must be remembered that careful search on many occasions, over as long a period as three months, may be necessary before the mycelium can be discovered.

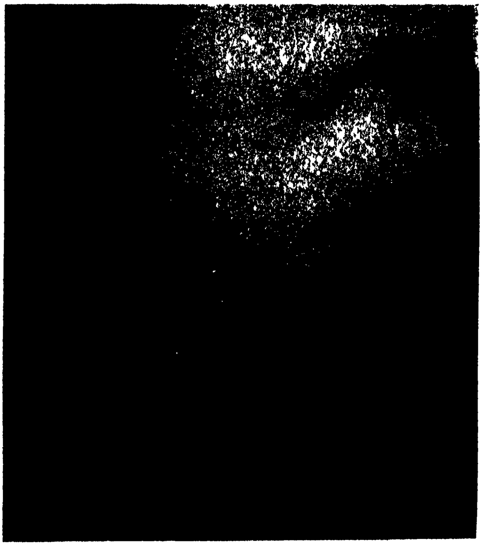


FIG. 56. Actinomycosis of chest wall secondary to disease in the abdomen.

In the cervico-facial type the disease is most commonly mistaken for tuberculosis, especially the keloid scars and sinuses after glands which may closely resemble the lesions seen in streptothrix infections; as also do gummatous infiltration and sarcoma, from which it is diagnosed by the slow progress, the many sinuses and the nature of discharge when these appear. Nodular leprosy and glanders may give rise to some passing difficulty in diagnosis. In none of these conditions does the chronic trismus persist unaltered.

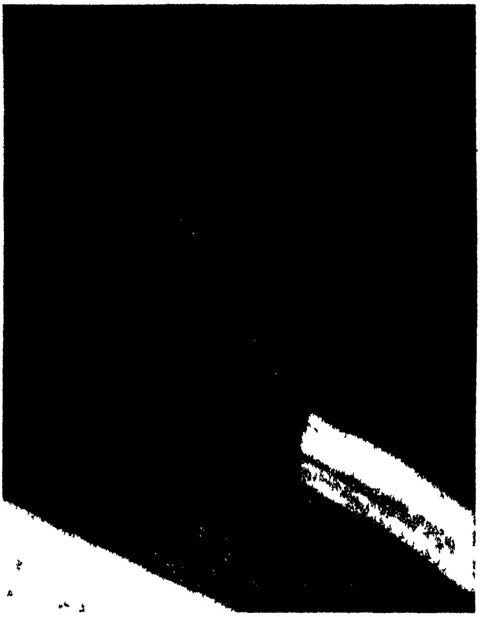


FIG. 57. Actinomycosis of neck and jaw.

The pulmonary type, as already stated, has to be diagnosed from pulmonary tuberculosis, gummatous infections, and mediastinal tumour invading the lungs.

In the abdominal type in the early stages the condition often simulates acute appendicitis; the appendix on removal may be wooden and œdematous, containing foci of pus, but often shows nothing to excite suspicion unless microscopically examined. At times the condition follows upon an actual acute appendix or appendix abscess. Such cases sometimes heal and do well for a few weeks, and then a mass appears in the right iliac fossa, persists, and ultimately breaks down with sinus formation (see Vol. II., Chapter XVII.).

The enlarged liver and wasting may give rise to a suspicion of amyloid disease or carcinoma, while actual amyloid disease often occurs.

Treatment. This consists in the early stage of complete and free excision of the infected area ; this, however, is not possible if the disease is far advanced, and in such late cases other means must be employed to destroy the streptothrix.

In situations where it is possible, as in the face and neck, the lesion and surrounding tissues should be freely injected with a 4 per cent. solution of formaldehyde, prepared by diluting the commercial strong formalin solution to a tenth its strength, and this injection may need repeating once or twice at an interval of three months. The treatment must be done under anæsthesia, as it is very painful. It is followed by considerable œdema of the area, which may take some weeks to subside. This method, which is very successful in curing the disease, cannot unfortunately be employed in abdominal and pulmonary cases, where, however, the sinuses and superficial tissues can be so treated. Deep-ray therapy and radium in massive doses give good results, 5 mg. needles being implanted in and around the infiltrated area for thirty-six hours ; these should not be used if septic sinuses are present, as sloughing results. In many cases one is forced to fall back on the older and unsatisfactory treatment with large doses of potassium iodide, ʒss—ʒi t.d.s., or copper sulphate gr. ¼, as a pill, t.d.s. ; salvarsan has also been tried, but without any convincing success, but successes have been reported with large doses of iodine in milk and by the administration of sulphanilamide which of course clears up any superadded sepsis. Vaccine treatment, which is difficult, as the streptothrices can be grown only with the greatest difficulty, has been tried with some measure of success, but not in enough cases to justify any statement as to the ultimate cure of the disease; it is, however, well worth trying in all internal cases.

MYCETOMA or MADURA FOOT

This is a streptothrix infection entering through abrasions on the feet of the natives of India and other tropical countries, and two varieties occur, the yellow, which is a true streptothrix infection, and the black, due to another variety of fungus.

Clinically, in both cases the foot becomes swollen and painful, numerous sinuses appear, and there is a discharge of thin pus containing black or yellow granules. The tarsal bones become infected and carious, the foot disorganised and the lower limb wasted. The progress of the disease is very chronic.

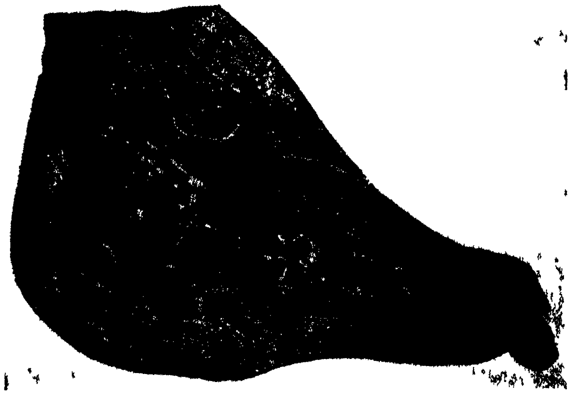


FIG. 58. Madura foot.

Treatment. This consists in amputation just above the diseased area. There would appear to be no record of the treatment of such cases by the injection of 4 per cent. formalin, which might be expected to give good results in early cases without extensive tarsal invasion. Radium probably would be of little use, as the bone is extensively invaded and sepsis often present.

Iodides are of no use in these cases, but sulphanilamides should be given.

IV. TOXIC INFECTIONS

These form a group of diseases the causative organisms of which have not yet been discovered, and they are therefore grouped as toxic infections, the whole body tissues being invaded, the main stress of the infection falling in most cases on the joints, and in many cases being manifested by skin eruptions. The majority of these conditions come under the care of the physician and only merit passing mention in a text-book of surgery.

Gout (Podagra). This is a condition of disturbed metabolism in which uric acid and other allied purin bodies are changed into sodium biurate, which is deposited in the tissues. The chief stress falls on the joints and bursæ, where the sodium biurate is found in the articular cartilages (Chapters XIX. and XX.), but not infrequently masses of biurate known as *tophi* may be deposited in the subcutaneous tissues, especially in the ear and hands; these quite often cause the skin to give way with the resulting formation of a gouty ulcer (see Chapter VII., p. 144).

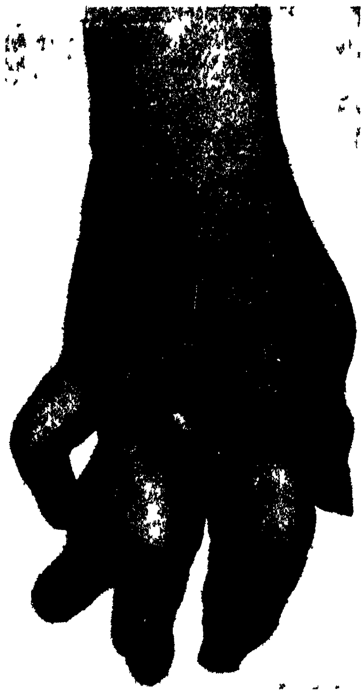


FIG. 59. Gout, showing tophi and gouty ulcers, with sodium biurate in the floor.

Treatment. This consists in rest during the acute stages, together with administration of vinum colchici, ♏xxx. t.d.s., till the acute pain ceases.

Acute Rheumatism (Rheumatic Fever). This is a disease usually affecting children or young adults, there being high fever, a furred tongue and acrid sweats, together with pain, swelling and effusion in many joints. Purpuric rashes may occur around these, or there may be occipital headache or abdominal pain due to inter-vertebral infection. Fibrous nodules may be present under the skin, and are of grave significance in prognosis.

The heart is usually rapid and may be irregular in action, the endocardium and myocardium being very liable to infection, with consequent valvular lesions, and their grave sequelæ; hence murmurs often can be detected by the aid of a stethoscope. The joint condition may present some difficulty in diagnosis, and will be dealt with in discussing the differential diagnosis of acute joint inflammations (Chapter XIX.) and of flat foot (Chapter XXI.). Chronic forms of rheumatism are also seen.

Treatment consists in rest and the administration of salicylates For full details reference must be made to a text-book of medicine.

Rheumatoid and Osteo-Arthritis. These diseases, which are probably stages of the same infection, form an extensive group about which little is at present known. The source of the infection usually would appear to be in the intestinal canal, such as pyorrhœa alveolaris, septic tonsils, chronic constipation, etc., the exotoxins from the organisms causing general debility and degenerative and inflammatory changes in many tissues, especially the fasciæ of nerves (lumbago and sciatica), and in and around joints (rheumatoid and osteo-arthritis). Inasmuch as the first indication of trouble is usually severe

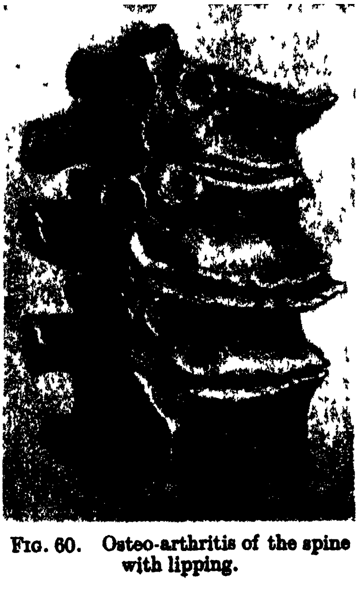


FIG. 60. Osteo-arthritis of the spine with lipping.

joint damage, it follows that treatment at this stage can only hope to remove further infection and is not likely to improve the local condition, which indeed may progress for a time in spite of it.

The conditions of the joints are dealt with in Chapters XIX. and XX., and for other points reference should be made to a medical text-book.

Zymotic Fevers. Measles, scarlet fever, etc., are only of interest to the surgeon in that the skin rashes are a manifestation of septicæmia, and so may be closely aped by the erythematous rashes which not infrequently occur in severe streptococcal or other bacterial septicæmias.

Moreover, in all these fevers severe inflammation of the bucco-pharyngeal mucosa occurs, which must not be confused with an ordinary catarrhal infection, as these zymotic fevers are highly infectious.

Again, pain and effusion, especially in the smaller joints, are a not uncommon sequel to zymotic fevers (especially scarlet fever and rubella), and must be diagnosed from rheumatic or diplococcal infections.

It would be out of place to devote further space to the consideration of these fevers in a surgical text-book, and the reader is referred to special works on the subject for further details.

V. PARASITIC INFECTIONS

This group comprises a series of diseases due to invasion of the body, usually through the gastro-intestinal mucosa, by various parasitic worms or their ova ; and inasmuch as the resulting lesions vary greatly in appearance and locality, the conditions need careful investigation with a view to efficient diagnosis and treatment. In all these infections examination of the blood shows a marked increase of the eosinophile cells to from 5 per cent. to 10 per cent.

HYDATID DISEASE

The Tænia echinococcus is a tapeworm of four segments about half an inch in length, which is found in the intestine of the dog ; the last segment, containing the ova, is about equal in length to the rest of the organism. The disease is very common in Iceland and Australia.

The ova are voided and enter the stomach of the man, usually from the handling of infected dogs, but occasionally by means of infected green salads, especially watercress, or possibly in infected drinking water, though as the ova sink to the bottom this is a doubtful source of infection ; in the stomach the shell of the ovum is set free and the embryo released ; this bores through the wall of the stomach and enters the blood vessels, whence it is borne to any part of the body, and there commences to grow.

In the human body, the alternative host of this form of tapeworm, the scolex stage of the tænia develops and large cysts are formed ; these may occur anywhere, but some 50 per cent. are found in the liver. The irritation of the growing cyst causes a reaction in the tissues, with the formation of a layer of fibrous tissue around the true cyst, the outer wall of which may become adherent to this false ectocyst. The cyst wall itself consists of an outer chitinous layer (*true ectocyst*), and an inner germinal layer (*endocyst*), from which bud off into the cyst cavity, which is filled with a clear fluid, a number of scolices ; these are the heads of tapeworms, which are only capable of developing into worms if eaten by a dog ; they have four suckers and a crown of hooklets, and are often single, but may occur in groups on a single stalk (brood capsules). Daughter cysts may be formed from the scolices in situ, and these are usually barren; thus the "mother" cyst may become filled with masses of "daughter" cysts lying in the cavity (*endogenous multiplication*). The fluid is clear, of low specific gravity (1,005–1,007) and contains a trace of albumen, and much chloride of sodium; if allowed to escape into the tissues or a serous cavity it causes severe urticaria, and other signs of toxæmia, as a result of an anaphylaxis being set up by the rupture of the cyst; microscopical examination of it reveals the typical hooklets. These cysts may persist for several years and reach an enormous size, causing trouble from pressure, especially in the brain, or they may become partially absorbed and calcified.

Occasionally the cysts multiply by budding out from each other (*exogenous multiplication*), and in this case there is no "parent" cyst apparent; this form occurs in bones (Vol. I., Chapter XVIII.), the lungs (Vol. II., Chapter XI.) (as distinct from the pleura), and rarely in the liver. The two main complications are the onset of infection and rupture of the cyst wall. These complications increase in frequency with the patient's age.

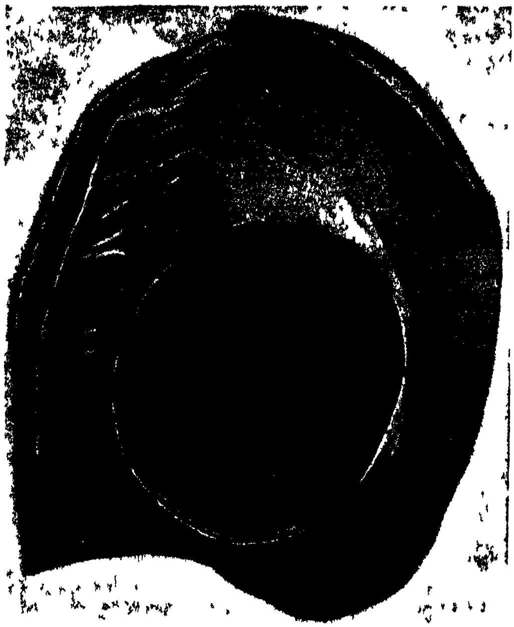


FIG. 61. Hydatid cyst of liver—endocysts collapsed.

Clinically the conditions vary in the tissues affected, but where hydatid cysts exist near the surface, percussion in many cases may elicit a hydatid thrill, due to vibration of the daughter cysts against the mother cyst wall. A more reliable test is found in the agglutination of the patient's serum by hydatid fluid (60 per cent. correct), and by a marked eosinophilia, which is common in all parasitic infections. The most reliable test, based on anaphylaxis, is the *Casoni* intradermal reaction (95 per cent. correct); here an injection of ·4 c.c. fresh hydatid fluid from a cyst, either human or from a sheep, is made intradermally and usually in about twenty minutes an urticarial wheal about the size of a shilling or larger, appears around the site of injection. The reaction may be delayed up to twenty-four hours and is of no value if the patient has been operated on previously for hydatids. The majority of these infections occur in childhood and remain very latent.

Treatment consists in removal where possible.

For details of these conditions see Parasitic Cysts (Chapter VIII., p. 224), and under the various organs—Liver (Vol. II., Chapter XVIII.), Brain (Vol. II., Chapter I.), Lung (Vol. II., Chapter XI.), etc.

TRICHINOSIS

This results occasionally from eating pork infected by the *Trichina spiralis*, a small round worm. This worm invades the muscles, especially those in the region of the shoulder girdle, in large numbers which later become encapsuled and calcified, showing as minute white specks through the muscle substance.

Clinically, in the acute stage there is some general malaise and maybe urticaria. The affected muscle, usually the trapezius, is swollen and tender ; on section it shows a pale œdematous appearance, and exudes a serous fluid in which the worms can be demonstrated microscopically. There is a history of a meal of pork usually within the preceding forty-eight hours.

Diagnosis may present some difficulty, and the affected muscle is liable to be incised under the belief that it is the seat of an acute myositis of a pyogenic nature. In chronic cases, where calcification of the worms has occurred, X-ray films will show up the calcified areas and clinch the diagnosis.

Treatment. This consists in rest to the affected muscle, purgation and the administration of santonin grs. v, followed by a second purge.

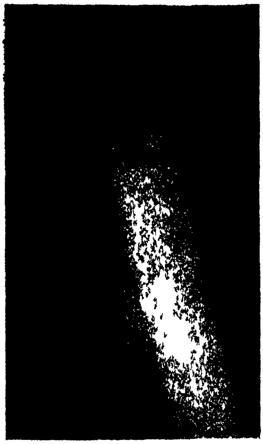


FIG. 62. X-ray film showing calcified Trichina spiralis in the muscles.

CYSTICERCUS CELLULOSÆ

The *Tænia solium* is a tapeworm met with in man, the cystic form being usually seen in the pig (measly pork) ; the cysticercus form is rarely seen in man, and then constitutes a series of small cystic swellings in the tissues, varying in size from a pea to a marble. They are of no importance unless occurring in situations where they give trouble from pressure (*i.e.*, the brain) or in the vitreous of the eye, where they may be detected on ophthalmoscopic examination. These cysts may become calcified.

The *diagnosis* can be confirmed by examination after excision, and is usually made accidentally following removal of a tumour thought to be a sebaceous cyst or a dermoid.

The *treatment* consists in excision where possible.

These are the chief members of the tapeworm group (or cestodes), the alternative forms of which are met with in man forming parasitic cysts.

BILHARZIOSIS

The *Schistosomum hæmatobium*, discovered by Bilharz, is a slender trematode worm, met with in the portal vein and its radicles. In this locality the female worm, during copulation, lies in the gynæcophoric canal of the larger male worm, which is about 1 cm. long. Thence the parasites pass to the mesenteric veins and invade the veins in the walls, especially of the rectum and bladder, but maybe of any other viscera, even being found in the lungs and subcutaneous tissues. Here they produce their ova, which by their irritation cause the formation of masses of granulation tissue, which project to the cavity of the bladder or bowel as soft velvety red masses, sometimes of great size, which bleed freely (see Vol. II., Chapters XIX. and XX.).

The ova are blunt ovoid bodies about 0·15 mm. long, having in most cases a terminal spike to their yellowish casing, though in many rectal cases a lateral spike may be met with. If they are placed in water, the shell ruptures and an actively motile miracidium emerges, which is covered with numerous flagellæ, by means of which it swims till it comes in contact with a water snail, when it is altered in form so that it is capable of penetrating the skin of anyone bathing, or the gastric mucosa in infected drinking water. The condition is common only in Egypt and the Middle East.

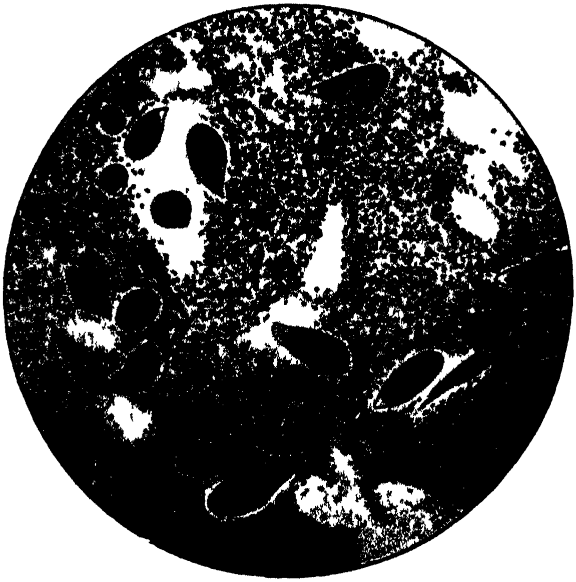


FIG. 63. Bilharzia ova in granulation tissue from bladder wall (× 100).

Clinically. The masses of granulation tissue usually occur in the bladder or urethra (Vol. II., Chapter XX.), or in the region of the rectum or anus, from which they may protrude in large bleeding masses, liable to be mistaken for piles (Vol. II., Chapter XIX.). They may also occur in the vulva, lungs (causing hæmoptysis), stomach and intestine, or subcutaneous tissues. The anæmia produced may be considerable, as the loss of blood is continuous and severe. The most common symptom is hæmaturia.

The *treatment* consists in weekly intravenous injections of tartar emetic in gr. ½ or gr. i doses till grs. xx to grs. xxx has been given in all. This effects a cure in most cases, but some few seem to relapse, when the dose may be repeated.

Local treatment to the granulations is usually unsatisfactory, but these rapidly disappear and heal after the tartar emetic treatment.

GUINEA WORM

The female *Dracunculus medinensis* is about 50 cm. long and yellowish white in colour, while the male worm is about half this length; both forms are met with in the human body as the result of infection from polluted drinking water, in which the young worms are found after the ovum has incubated for some weeks in the Cyclops quadicornis, a small crustacean. The disease, which is confined to the tropics, usually manifests itself about a year after infection, when the female worm appears under the skin, usually of the feet or legs, and penetrates this to deposit the eggs into water; the ova are discharged from the uterus, the duct of which opens into the œsophagus, *via* the mouth.

Clinically, the first sign is usually the appearance of a painful, red, subcutaneous swelling, which soon ulcerates, forming a small sore about ½ inch across, in the centre of which is a tiny opening, sometimes blocked up by the worm's head, from which ova and a milky fluid are discharged. General symptoms are usually slight.

The *treatment* consists in bathing with cold water, which, besides allaying irritation, hastens the ejection of the ova, and ultimately of the worm, which as it appears should be tied to a small stick and wound gently out; the whole process of extraction takes from four to ten days, and must be very gently conducted to avoid rupture of the worm, a disaster resulting in severe cellulitis, and even infective gangrene of the part.

FILARIASIS

This is a condition met with in tropical regions and is due to the presence of the *Filaria Bancrofti*, a hair-like round worm about 3 inches long, in the lymphatic vessels; the worms occur in masses in the larger lymph trunks, which they may completely block, causing extensive lymphatic œdema of the tissues distal to the infected area—a condition known as *elephantiasis* (see pp. 250, 311 and 312).

The embryos escape into the blood stream, where they are found at night, and in the form of slender worms tapering at one end, about $\frac{1}{80}$ inch long and known as *Filaria nocturna*, they are taken up by mosquitoes, which in their turn reinfect man. This form is seldom found in the blood in old-standing cases, due probably to the complete lymphatic blockage precluding their entry into the circulation.

Clinically, the results produced depend on the tissue reaction to the irritation of the worms in the lymphatics and the efficiency of the collateral lymph circulation. The stress of the œdema usually falls on the skin and subcutaneous tissues, which present in the early stages the typical signs of lymphatic œdema—a hard non-pitting white œdema, the mouths of the glands being very obvious in the skin; later the whole skin and subcutaneous tissues hypertrophy and become rough and rugose, enormous deformity resulting. The lower limb and penis and scrotum are most commonly affected, but the abdominal parietes and even the retro-peritoneal tissues may be involved.

Rarer conditions resulting are a septic lymphangitis; the formation of localised abscesses usually about the groins; the appearance of chylous ascites, chylous hydrocele or chyluria following obstruction of the thoracic duct and rupture of dilated abdominal lymphatics (the fluid in these cases resembling milk in appearance); infection of the synovial membranes or bursæ, and very occasionally of the testis, may occur.

Diagnosis is usually easy, and the discovery of the dead or living worm or embryo clinches it.

Treatment. This in the acute stages consists in intravenous injections of tartar emetic, which destroys the parent worms as well as the embryos, but of course does not ameliorate any lymphatic obstruction which may have occurred. The elephantiasis of the scrotum and penis can be dealt with by stripping the œdematous skin and subcutaneous tissue from the underlying organs, and either leaving these to granulate and heal over, or grafting them.

In the lower extremities amputation has frequently to be resorted to, but in milder cases the excision of large strips of skin and subcutaneous tissue, with suture of the wound, may be carried out, and is sometimes sufficient (see pp. 309, 313).

AMŒBIC INFECTIONS

These come more properly under the physician, but inasmuch as the *Amœba hystolytica,* besides causing ulcerative colitis and dysentery by burrowing in the submucous tissues of the large bowel, subsequently may cause extensive strictures of the rectum and colon, the condition is not without interest to the surgeon, who may be called on to treat hæmorrhoids (Vol. II., Chapter XIX.) or even acute obstruction (Vol. II., Chapter XVI.) due to this cause.

Moreover, the amœba not infrequently infects the liver, and more rarely the kidney or lung, giving rise to *amœbic abscess* in these situations.

Clinically, the disease can be recognised in the acute stages by the passage of frequent purulent and mucoid stools swarming with amœbæ, and later by the development of signs of obstruction such as piles, or alternating constipation and septic diarrhœa, following on fibrosis and contraction in the colon wall. The presence of an amœbic abscess is to be suspected after such an attack, when the patient wastes steadily, the skin assumes a dull earthy hue, and a swelling develops in the hepatic area (Vol. II., Chapter XVIII.).

The *treatment* consists in rest in bed on a fluid diet in the acute stages, combined with the administration of emetine, gr. i daily by subcutaneous injection, or by the mouth in the form of bismuth emetine iodide ; this treatment is usually successful in causing absorption of amœbic abscesses should they occur. Should it fail to do so, aspiration of the chocolate brown pus, or incision and drainage, may be carried out.

CHAPTER VII

ULCERATION AND GANGRENE

Ulceration, as already stated in Chapter V., p. 70, is the result of inflammatory reaction to a bacterial infection on or near the surface, causing a molecular or cellular death of the superficial epithelium, which disintegrates and disappears, usually without showing any obvious mass of dead tissue (slough). An analogous condition occurring in bone is known as *caries*, and here the gradual absorption of the dense bone by granulations in the Haversian canals leads to a general rarefaction of the tissue.

Gangrene, on the other hand, is a condition in which, when, from any cause, death of tissue results, an obvious large mass of dead tissue is present, and it may well be described as " death in bulk." When occurring in bone it is customary to speak of the condition as one of " *necrosis*."

An ulcer is an open wound which tends to persist as a result of the presence of the organism causing the infection, and according to the nature of this organism and the length of time the sore has persisted it is customary to classify ulcers under the following headings :—

Acute	**Chronic**
I. **Pyogenic and Traumatic.**	
1. Staphylococcal or streptococcal.	The same, and any cause of malnutrition of the part concerned.
2. Heat—Chemicals—Electricity.	
	Callous Ulcers
	1. Vascular Congestion—Varicose veins.
	2. Foreign Bodies—Gouty tophi.
	3. Nerve Lesions—Trophic ulcer, Bedsore.
II. **Specific.**	
1. Tuberculosis.	1. Tuberculosis—Lupus, Bazin's disease.
2. Syphilis—First stage, second stage, third stage.	2. Third stage (gummata).
3. Soft Chancre—Ducrey's Bacillus.	3. Streptothrices.
4. Typhoid 5. Amœbic 6. Choleraic } In bowel only.	4. Amœbæ in bowel.

III. **Malignant** :—

Where the ulcer is due to the invasion and destruction of the epithelium by a malignant neoplasm in or under it.

1. Carcinoma.
2. Rodent ulcer.
3. Sarcoma.

It is obvious that if for any reason, such as a nerve lesion or congestion and malnutrition from varicose veins, or the presence in the tissues of an excellent culture medium such as sugar in diabetes, the vitality of the tissues is impaired, then infection is far more prone to give rise to ulceration, and the process is likely to take a very long time to repair.

Some surgeons prefer to classify ulcers from the clinical standpoint into the following types :—

(1) **Spreading ulcer,** wherein infection has still got the upper hand. There is a profuse discharge, the granulations are scanty, and the edges red and œdematous ; considerable pain and enlargement of the nearest lymph nodes are usually present.

(2) **Healing ulcer,** where the inflammatory reaction of the tissues has overcome the infection. Here the discharge is slight, granulations are forming freely, the edges of the area are no longer inflamed, and a single layer of epithelium may be seen spreading in over the granulations ; this may be known by its bluish colour. Hence the healing ulcer shows a transition from its centre outward of red and blue, and thence to white where the skin is normal around.

(3) **Callous ulcer** is a term applied to any ulcer which has been present for a long time in an unhealed condition. The granulations are usually pale and scanty, the tissues on which the ulcer is situated much indurated, and the surrounding skin often deeply pigmented and scaly. Such ulcers are often given a confusing variety of names, such as varicose ulcer (when complicating varicose veins), trophic ulcer (when a nerve lesion is present), gouty ulcer (when uric acid is present in the floor in gouty subjects), lupoid ulcer (when due to tubercle), etc., but it must be recognised that these are only types of a callous ulcer.

As has been already pointed out (p. 70), when describing an ulcer the terms in common use are :

1. *The floor :* applied to the visible area denuded of epithelium, which may be, in the active stage, covered by small masses of dead tissue (sloughs), but later covered by masses of capillary vessels and delicate connective tissue bright red in colour, and known as granulation tissue. From this tissue there exudes a discharge which frequently clots and forms a scab which hides the granulations. In malignant ulcers no true granulations are present, the floor consisting of breaking-down growth.

2. *The base :* a term used to denote the tissue lying beneath and around the ulcer, and on which it is situated. This may be much indurated by the formation of fibrous or even cartilaginous tissue in old-standing ulcers. In some cases, especially in malignant ulcers, the base may consist of bone.

3. *The edges :* the boundary limiting the granulating area from the surrounding skin ; in regard to which the general outline of the ulcerated area should be noted, and the condition of the skin, as to whether inflamed, raised, everted, clear-cut or under-cut, and whether free from the floor, or intimately connected with the granulations.

4. *The discharge* from the ulcer should be examined as to its nature, and the type of organisms present.

(I.) **Pyogenic or traumatic ulcers** are sometimes due to destruction of the epithelium by the direct action of an acid, alkali, or an electric or heat burn ; in these cases a clean wound occurs, which, however, is very liable to infection of the damaged tissue by organisms in the surrounding skin, or from the air. In other cases the entry of organisms into an unnoticed abrasion, especially if for any reason the local resistance of the tissues is lowered, as in venous congestion, nerve lesions, etc., may lead to the formation of an ulcer, or the condition may follow the cutting off of the blood supply in the subcutaneous tissues, as in carbuncle.

From whichever cause the ulcer arises, the *clinical signs* are very similar in the acute stage. The floor is yellowish white in colour, and covered with pus and small sloughs, no granulations have yet formed, and the removal of the pus reveals the subjacent tissue cells in a state of œdema from inflammation. The edges are red and the surrounding skin swollen and tender, showing all the signs of acute inflammation (*q.v.*, p. 19). There is frequently a thin irritating discharge (ichor), and the neighbouring lymph nodes are painful and tender.

Under favourable circumstances this condition improves and passes into the *healing stage*, where the floor becomes clean and covered with red granulations, the base is less indurated, the edges cease to be inflamed, the epithelium grows in over the raw area, and the discharge diminishes or ceases; but if the conditions are adverse the ulcer may spread rapidly, both superficially and deeply, into the tissues, which are extensively destroyed, a condition known as **phagedæna,** and where repair when it occurs is accompanied by extensive deformity and scarring.

The *treatment* of an ulcer is to keep the affected area at rest and elevated, and apply some non-irritating antiseptic dressing, which must be frequently changed, to the ulcer itself. Weak carbolic or mercurial lotion or hypertonic saline are equally efficacious. Warm baths are both soothing and serve to remove discharge; they are particularly valuable if phagedæna supervenes. Sloughs can be assisted to separate by dressings of chlorinated soda lotion, but inasmuch as the chlorine destroys growing epithelium, these should be discontinued as soon as the floor of the ulcer is free from dead tissue.

As soon as the ulcer is clean, healing should be encouraged by the application of some stimulating lotion containing zinc salts, such as lotio rubra, or the zinc, alum and glycerine lotion given on p. 71.

Should *phagedæna* occur prompt treatment is necessary in the way of antiseptic baths and removal of sloughs, but such drastic treatment as curetting or painting with fuming nitric acid is seldom called for.

The **chronic pyogenic ulcer** calls for no particular description, beyond noting that it is one of the commonest and frequently most intractable conditions that the practitioner is called upon to treat among elderly working-class patients, especially in women (such a condition having been present for years, usually in the lower part of the leg). It differs from the acute ulcer in that the granulations are pale and weak, the base is much indurated, and there is a marked pigmentation around the ulcer, the skin being scaly and unhealthy; but it is worthy of note that in a fair proportion of even the most obstinate cases either the granulations are still of a good red colour, or marked induration is absent, and in these a syphilitic element should be strongly suspected, and antisyphilitic treatment combined with the local treatment of the ulcer, when in the vast majority of cases healing will occur.

Treatment consists, firstly, in resting the limb continuously in an elevated position, and, at the same time, cleaning the ulcer by means of strong antiseptic lotions, such as chlorinated soda, and then applying stimulating lotions, such as zinc salts, combined with support and rest. This may best be achieved by putting the patient to bed, but frequently this is impracticable, when a very satisfactory compromise may be arrived at by the application to the area, after the ulcer is clean, of Unna's paste This consists of :—

Zinc Oxide	6 parts
Glycerine	12 ,,
Gelatin	4 ,,
Water	16 ,,

It requires melting in a glue-pot, and then applying with a brush, at a temperature just warm to the back of the hand, to the ulcerated surface and surrounding area, which is then enswathed in several layers of sterile bandaging on to which Unna's paste is carefully painted with the limb elevated.

In the case of an ulcer of the leg, the ankle and foot must be included in the bandage, which should be carried up to just below the knee, which, however, often need not be included. Such a dressing usually needs changing weekly at first, but later lasts two or three weeks, and should be continued for at least a fortnight after the ulcer has healed, when a crêpe bandage should be substituted and worn for at least three months.

Alternatively, one of the elastic webbing bandages (elastoplast, or varicosan) coated with dressing may be applied to the elevated limb. These need changing about once a week, and care must be taken lest the surrounding skin becomes very sore.

In cases where the ulcerated surface is very foul the cleansing process may be greatly accelerated by a preliminary application of pure formalin, which kills all the superficial tissues, and leaves a clean granulating area on separation of the black slough.

Should the above treatment fail to heal the ulcer, veins leading from the ulcer should be injected, when rapid healing usually occurs, provided there is no valvular incompetence.

Skin grafting has been much used, when the ulcer is clean, Thiersch's method giving the best results, but inasmuch as the poorness of the blood supply to the region is the main cause of the persistence of the ulceration, no very good results are to be expected from this method.

X-rays, ultra-violet rays, and radium emanations are also useful in stimulating tissue growth, and so promoting healing, but they must be used only by an experienced radiologist, as in excessive doses they cause extensive ulceration and death of tissue (Chapter XXIII.). In cases where the granulations are very poor, their growth can be well stimulated by the daily application of scarlet-red ointment to the ulcer and surrounding tissue.

There are, however, many cases of chronic septic ulceration in which, either owing to the length of time the lesion has been present, the amount of sepsis, the low resistance of the tissues, or the supervention of malignant disease, healing will not take place even with the most lengthy and painstaking treatment, and there is another class of case in which, although healing will occur slowly while the patient is at rest, the scar breaks down so soon as the patient moves about.

In both these cases the defeated surgeon will have to resort to amputation, and it must be borne in mind that owing to the low resistance and chronic infection of the tissues in the immediate vicinity of the ulcer, it is wise to ablate the limb through healthy tissue in order to ensure healing, and that even under these circumstances suppuration is not uncommon from the disturbance of the chronically infected lymphatics.

It should be noted that non-healing may result from the presence of a foreign body in the floor of an ulcer; in such a case the granulations are usually excessive; if it is at the bottom of a deep wound the ulcer is healed all except a small central area, from which protrudes a mass of granulations (button granulation), and whence a track lined with granulations leads down to the foreign body. Such a condition is known as a **sinus.** Treatment consists essentially in localising and removing the foreign body, and in this an X-ray film is often invaluable for demonstrating the size and position of the cause of the sinus.

There are two varieties of ulceration under this heading which merit especial mention :—

(*a*) **Varicose ulceration** occurs always in the lower half of the leg, and usually starts on the inner side just above the internal malleolus. There are usually many superficial varices in both legs, the skin being cyanotic, unhealthy and covered with the scabs of a chronic infective dermatitis which renders it scaly and discoloured; it may be exuding a sticky, sero-purulent discharge (**varicose eczema**).

The whole condition arises from an infection of the unhealthy and improperly nourished skin, in which the inflammatory reaction is feeble, but usually results in death of the surrounding tissues and consequent spread of the infection (p. 287), which persists often for years and gradually spreads up and around the leg.

Such ulcers, if of old standing, often go down to and infect the bone, which shows all the changes characteristic of a chronic septic osteoperiostitis (Chapter XVIII.): they not infrequently become the seat of malignant changes, carcinoma or sarcoma supervening, in which case immediate amputation is indicated.

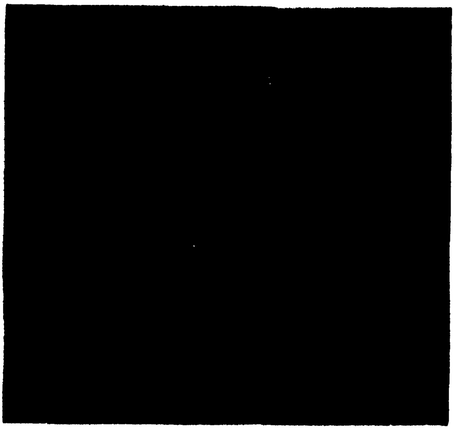


FIG. 64. Varicose ulcer. Note pigmentation of ski

Treatment is on the same lines indicated for all chronic ulcers; as a general rule, the main veins leading from the ulcer should be injected and so clotted (p. 288), while if a cough impulse is present in the internal saphena vein, Trendelenburg's ligature should be performed. This treatment is usually followed by rapid healing of the ulcer, but a supporting bandage may with advantage be prescribed. An Unna's dressing or elastoplast bandage is often most valuable in the treatment of varicose ulcer, and if this fails many ulcers may be made to heal by really tight strapping applied round the leg continuously below, over and above the ulcer.

Where one or two enlarged varicose veins exist above an ulcer, these should be injected with 5 per cent. quinine, when the ulcer often improves and even heals completely; injection must never be attempted through varicose eczema or into blue subcuticular venules; it is useless, moreover, if a thrill is present in the vein when the patient coughs (see Chapter X., p. 290).

(*b*) **Trophic ulceration** occurs in areas the nerve supply to which has been partially cut off either from injury or disease in the central nervous system, or lesions of the peripheral nerves (p. 248, also Chapter XII. and Vol. II., Chapter IV.).

Complete division of a peripheral nerve is not followed by ulceration, but it must be remembered that after suture, when the nerve is recovering, the lesion is converted into a partial one, and so ulceration may occur.

One of the best known examples of this type of ulceration is the **bed sore,** and, as is generally known, these are very intractable to treatment, and indeed spread extensively in spite of it. Bed sores usually occur over the pressure points, which in a bed-ridden patient are the areas over the trochanters, sacrum and heels. The skin here becomes red and shiny and soon gives way, exposing the subcutaneous tissue; muscles and bone often become involved, and there may be extensive sloughing.

Treatment is mainly prophylactic; the patient's position should be changed frequently, the skin hardened with methylated spirit, and the circulation encouraged by gentle massage; if the patient is incontinent every effort should be made to keep the skin dry and clean. In cases of nervous disease, in spite of all precautions, bed sores often occur, and then should be treated with chlorinated soda dressings till all sloughs have separated, after which dry dressings or aristol powder may be applied.

Such sores seldom heal, and in cases of central nervous disease, such as poliomyelitis, where trophic sores exist on a limb, ablation of the limb has usually to be resorted to if a cure is desired.

In cases of peripheral nerve injury the ulcers heal slowly as the nerve recovers, but their care is often a cause of great anxiety to the surgeon. In cases of old-standing neglected nerve lesions, or in the ulcerative form of leprosy, amputation should be practised if the affected area can be so treated.

Skin Grafting. It will not be inappropriate at this stage to say a few words on the subject of skin grafting, which is a term given to certain procedures in which portions of skin are applied to a granulating surface in order to procure more rapid epithelialisation and so prevent contractures in the scar. In order to be successful it is necessary that the graft be taken from the patient himself (autogenous graft), or from some other individual with a similar blood group (*q.v.*, p. 54), and that the area to be grafted be surgically clean. For the ensuring of this latter, it is often necessary that cultures should be taken from the granulating area; the presence of a few staphylococci on two successive occasions is not necessarily a bar to

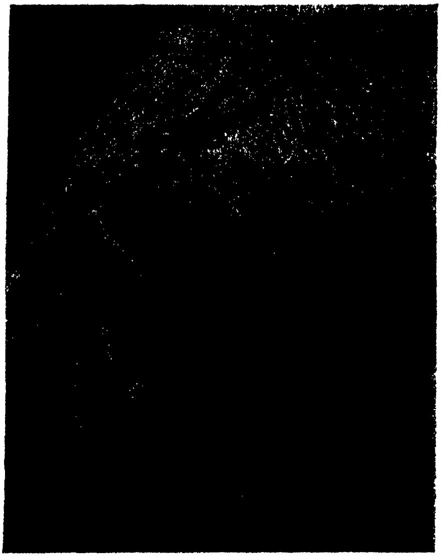


FIG. 65. Thiersch grafting (the same case as Fig. 142).

operation, but if other organisms are present further steps must be taken to clean the area.

It will be seen that this method is particularly applicable in hastening the closure of wounds where a large area of skin has been destroyed, such as lacerated wounds, burns or ulcers, and, moreover, has the additional advantages of providing normal epithelium to cover the area and of preventing extensive contracture in the area, with consequent deformity. As has been pointed out already, in areas such as chronic ulcers, where the blood supply is poor, good results cannot be expected, as the skin grafts frequently fail to take.

Procedure at Operation. The skin area from which the graft is to be taken should be prepared as for an operation and the graft cut with a sharp razor. The graft may then be applied directly to the raw area, where hæmostasis must have been efficiently procured. In the event of granulations being present, these may be curetted away, or left *in situ* undisturbed; probably the latter procedure gives the better result. The graft, having been placed, raw surface down, in contact with the granulating surface, must be carefully smoothed out and pressed home so as to exclude all air, and care must be taken that the edges are not rolled under. It may then be left *in situ*, and will adhere tightly, needing only the protection of a frame to prevent the patient accidentally rubbing it off, or it may be covered with protective tissue (the blue variety being preferable to the green) and left undisturbed for ten days. The area from which the graft is cut should be dressed with a tannic acid compress, which makes a painless dressing, and should be left undisturbed for at least a fortnight.

FIG. 66. Tuberculous ulcer.

Methods. There are several methods of skin grafting in common use.

Thiersch grafting is commonly practised, and is of the greatest practical value. It consists in the application of large areas of epithelium, cut so as just to include the tips of the papillæ of the true skin; slight bleeding will result in the area whence the graft has been cut. Such grafts may be 2 or 3 inches square, and several should be applied to the raw area, the edges of which they overlap. Care must be taken that the edges of the grafts do not roll under, as they have a great tendency to do. Such grafts are usually taken from the thigh.

Reverdin's grafting is the original method; it consists in the transplanting of numerous islets of epithelium on to the raw area. These may be snipped off with scissors around the base of an uplifted hair.

Wolfe's grafting differs from the preceding methods in that the whole thickness of the skin is employed, with all subcutaneous fat carefully removed from it. Such a graft needs stitching into position, and in situations where it is desired to graft from a limb to the face or trunk some form of *pedicle graft* may be employed, the skin being left attached to its original site by a pedicle to maintain the nutrition of the remainder of the graft which is stitched in position, the limb being held in plaster. At a subsequent operation, ten days to three weeks later, the pedicle is severed.

A similar method is seen in the rolled-in "*cigarette or tube graft*," which is raised from the underlying skin, except at both ends, and rolled up like a cigarette; later one end is cut free and implanted further away, and after another ten days the other end is implanted further away; this process can be repeated almost indefinitely, and a graft thus conveyed from one area to another, keeping an intact blood supply, by a series of operations at ten-day intervals.

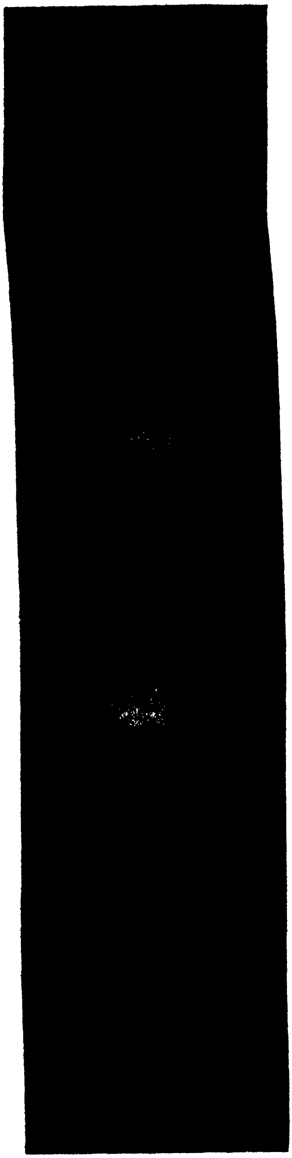


FIG. 67. Gummatous ulcers.

(II.) Ulcers resulting from infection with a specific micro-organism will be dealt with fully under the appropriate headings, as the ulceration is frequently only the manifestation of a cutaneous lesion in what is a general infection throughout the body. It is therefore very essential when examining any ulcer to determine whether it is entirely or partly specific in origin, and if so to determine firstly what treatment is necessary for the cure of the general specific infection, apart from such local treatment as may be appropriate to the condition of the ulcer itself.

It may be helpful, however, at this juncture to indicate briefly the salient points of the specific ulcers commonly met with in surgical practice, and let it be realised clearly that these are due usually to syphilis, tubercle, or soft sore in the order named.

(*a*) **Syphilitic ulcers** may occur in any stage of the disease (see also p. 237).

(1) **A primary sore** is usually on or around the pudenda, but may occur in any situation. It is often an indolent ulcer on a raised and indurated base, thus earning the name "*hard chancre*"; the nearest lymph nodes are invariably enlarged, discrete, movable and not tender, nor do they ever suppurate or soften.

(2) **Secondary ulcers** are usually met with on the mucous surface of the mouth or fauces, which are generally injected, and they should be carefully looked for in any case of persistent sore throat in a young person. They are superficial, spreading ulcers, usually glistening from adherent mucus, and well merit their title of "*snail track ulcer*." Fissure-like ulcers, with œdematous edges, may exist in the moist areas around the mouth and anus and occur with *condylomata*.

(3) **Tertiary ulcers** usually arise from the breaking down of a subcutaneous necrotic area called a *gumma*, and are primarily circular in shape with steep clean-cut edges, and a floor covered with a yellow wash-leather-like slough

of the dead gumma; this subsequently disappears, leaving exposed granulations of a typical bright red colour. Frequently several gummata coalesce, and the resulting ulcer has a crescentic outline, due to the coalescence of circles of various sizes. Such ulcers may cover an extensive area, and are characterised by a tendency to heal and then break down again. The scars of a healed gumma are dead white, thin and papery, and usually circular in outline.

It must not be forgotten that a gummatous element may exist in any chronic ulcer, a condition indicated by the persistence of abnormally red granulations in the floor of an otherwise callous ulcer.

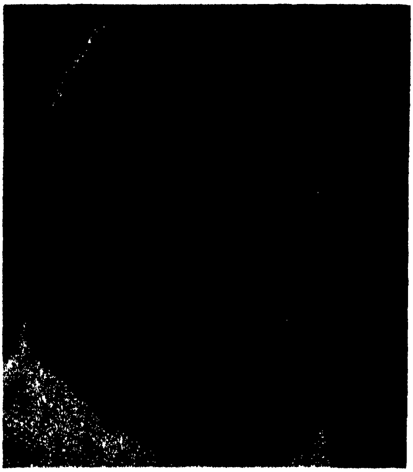


FIG. 68. Lupus vulgaris.

(*b*) **Tuberculous ulceration** may occur on the skin, when it usually follows the breaking down of caseous subcutaneous lymph nodes, and is, therefore, commonly met with in the neck, axilla or groins. (There is a variety met with on the backs of the calves of young people, usually symmetrical and known as *Bazin's disease;* there is, however, some doubt if these ulcers are tuberculous in origin.) It is also met with in the mucous membrane of the larynx and tongue (usually on the dorsum) secondary to pulmonary tuberculosis. In whichever situation they occur, these ulcers are painful, small, and their edges undermined. The floor is covered with pale œdematous granulations, and the surrounding tissues are bluish in colour and slightly œdematous. Healing is frequently retarded by the presence of caseous material in the base, or secondary pyogenic infection.

FIG. 69. Malignant ulcer of chest wall.

Lupus is a condition of very chronic ulceration of the cuticle due to infection of the superficial layers of the dermis by the tubercle bacillus. It is characterised by great chronicity, frequently multiplicity of lesions, and healing in the centre of the area, the edges of which are slightly ulcerated, and the surrounding skin nodulated and showing clear brownish areas of subcuticular granulation (apple jelly nodules).

The condition may affect skin or mucous membrane, and if untreated will cause extensive destruction of deep tissues and consequent revolting deformities. Epithelioma not infrequently may supervene in old-standing cases, and is of a very malignant type.

Treatment consists in excision and skin grafting where practicable, or, failing this, curettage, which may be followed by exposure to X-rays, ultra-violet rays or radium emanations. Where a raw area results from operation, a tannic acid compress makes an excellent and painless dressing.

(*c*) **Soft chancre** is always met with in or around the pudenda, and appears within a day or two of infection. Due probably to Ducrey's bacillus, the lesion consists of shallow, oval clean-cut ulcers, which are often multiple. The neighbouring glands are enlarged, matted and tender, and frequently suppurate.

The condition may become phagedænic if not treated.

(III.) **Malignant ulcers** occur, as has been pointed out already, not as the result of an inflammatory reaction to an infection, but from the actual invasion and destruction of the cutis by the tumour. They will be dealt with fully in the appropriate place (p. 242), but it may be borne in mind that as they are the result of tissue destruction by a tumour, the edges of the ulcer will be merged with the tumour, which will be obvious in the surrounding tissues, and that, moreover, the floor of the ulcer is covered, not with granulation tissue, but with sloughing growth. The edges of such malignant ulcers are usually raised, everted, and very hard, and the ulcer increases rapidly in size.

GANGRENE

Gangrene, as has been previously explained, is a term used to denote death of portions of the body visible to the naked eye; if it is confined to the soft parts only it is frequently called "sloughing," the dead tissue being known as a "*slough,*" or if confined to bone it is called "necrosis," the dead bone being named a "*sequestrum*"; gangrene is, therefore, usually applied to death affecting simultaneously both hard and soft tissues.

Clinically, gangrene may be met with in one of two forms :—

1. Dry,
2. Moist: (*a*) aseptic, (*b*) septic,

but whichever form is met with there are certain signs present indicative of death of tissue, and these are :—

1. Absence of pulsation in the arteries of the part, and failure of restoration of colour after pressure.

2. Loss of sensation: this is complete when death has supervened, but owing to anæmia of the end bulbs during the process, great pain may be experienced while death is occurring.

3. Loss of temperature: owing to there being no blood supply the part will be stone cold.

4. Loss of function: owing to death of the tissues the part will be useless and motionless.

5. The colour may be waxy white, due to absence of blood; mottled or blotchy and of a purplish hue, due to decomposing blood; or black, due to changed blood pigment.

Threatened Gangrene. All these changes may be observed to some extent in an area in which gangrene is threatened, and their detection calls for active treatment to endeavour to restore the circulation and avert the disaster.

This may best be achieved by elevation of the part, which should be kept warm and clean; gentle massage or faradic stimulation will further assist in maintaining the circulation; periarterial or lumbar sympathectomy is sometimes of benefit.

In cases where gangrene has supervened it may be either :—

(1) **Dry Gangrene.** This only occurs in those cases where no infection is present, and where the cutting off of the blood supply has been a gradual process, so that when the arterial stream finally ceases there will be no flooding of the area with venous blood due to the *vis a tergo* from the heart, as always follows if the arterial pressure is suddenly cut off ; moreover, this condition usually only persists in situations where there is but little soft tissue, such as the hand or foot, as death of much tissue results in the formation of liquids which cannot evaporate sufficiently rapidly to ensure mummification of the part. Dry gangrene is usually met with in old people with arterial sclerosis (senile gangrene), but may follow injuries to fingers and toes if both artery and vein are divided simultaneously.

The signs of dry gangrene are those of death of the part, which becomes hard and wrinkled, and usually dark brown or black in colour, due to diffusion of blood pigments. Frequently no definite " line of demarcation " is seen in this type, as the inflammatory process is sufficient to cause thrombosis in the vessels of the surrounding tissues, and so the condition spreads, thus earning itself the name of " spreading gangrene." As has been explained, a dry gangrene of the foot or hand is often present contemporaneously with a moist gangrene of the leg or forearm.

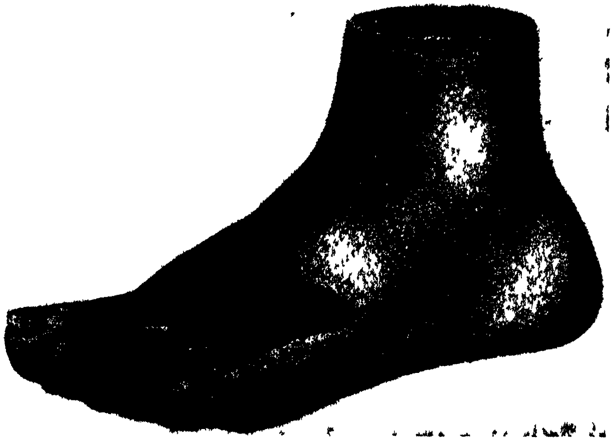


FIG. 70. Gangrene (dry) of the foot, showing line of demarcation.

(2) **Moist gangrene** is more commonly met with, and results either from :—

(*a*) The sudden cutting off of the blood supply where the blood pressure has not been previously diminished locally, and consequent flooding of the area with venous blood from back pressure ; or the liquefactive degeneration in a bulk of soft tissue causing fluid to accumulate beneath the skin at a greater rate than it can evaporate. In both these cases *aseptic moist gangrene* is seen.

(*b*) *Septic moist gangrene* is more commonly met with, and may result from either infection of the moist dead tissue in aseptic moist gangrene, and less commonly in dry gangrene, or be due to a primary infection of the tissues with pathogenic organisms, the toxins from which cause the death of the infected part. This may occur either from lowered vitality of the tissues, as when gangrene already exists, or nerve lesions are present (bed sores), from the presence in the tissues of some abnormal constituent, favourable to the growth of organisms, as in diabetes, or from the extreme virulence of the toxins, as in the gas-forming anaerobic organisms met with in gas gangrene.

The signs of moist gangrene will vary according to whether infection is present or not. Besides the signs of local death, there will be a moist, blotchy skin, which is frequently raised from the surface by bullæ filled with serum. Crepitus may be present from the presence of gas in the cellular tissue ; there is usually a good " line of demarcation."

If sepsis occurs all these signs are much more marked, there is usually more gas and a most offensive putrescent odour. Inflammatory reaction is usually marked in the living tissue. Severe constitutional signs are common, and death may supervene rapidly from septicæmia.

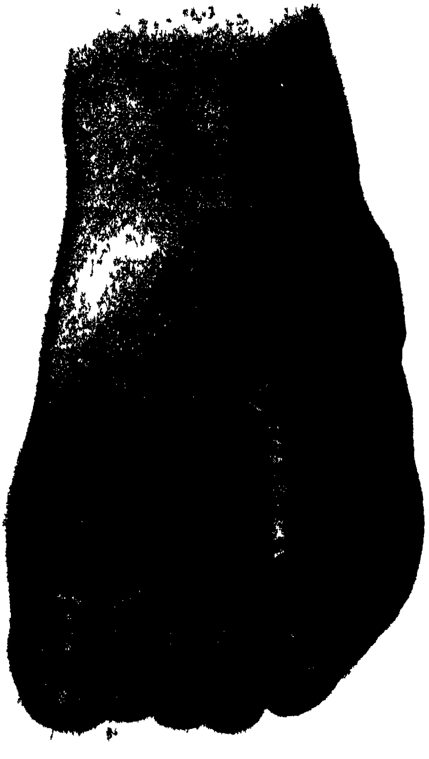


FIG. 71. Early moist gangrene of the foot commencing in a soft corn on the little toe.

Treatment. It will be seen from the foregoing that once gangrene has occurred, every effort must be used to keep the part aseptic and dry, to ensure which it should be elevated, wrapped lightly in cotton wool after dusting with boracic or iodoform powder, and suspended in a cradle warmed with electric lamps or hot bottles to promote evaporation.

Constitutional treatment usually resolves itself into care of the general health, and the administration of sedatives for the pain, which may be excessive and often needs morphia. Nocturnal delirium is not uncommon, and a certain amount of toxæmia and temperature, which can only be cleared up by the removal of the dead part. Treatment is dealt with more fully under the various pathological types of gangrene.

The subsequent fate of the gangrenous mass depends on its bulk and upon whether it is infected or no.

1. *Small areas of dead tissue,* if aseptic, may get absorbed by a process of inflammation in the surrounding tissue, to which they act as a provocative irritant—such is the fate also of small aseptic foreign bodies, such as catgut ligatures. This process may be observed in the case of small sequestra, and areas of sloughing at the edges of amputation flaps.

2. *Larger masses,* if aseptic, become gradually separated from the living tissue by a process of ulceration at the line of contact. This process takes place at the expense of the dead tissue, and inasmuch as the blood supply is more adequate in the muscle and bone, these separate more distally than the

skin, and so in a case of gangrene left to separate naturally a "conical stump" results, the deeper parts projecting beyond the skin. This ulcerative line at the junction of the dead and living tissue, with its red granulations, is very obvious, and known as the **"line of demarcation"**; as has been pointed out, it is poorly marked or absent in cases of gangrene due to vascular degeneration, where the effort at tissue reaction is sufficient to cause death of the living tissues.

3. In cases where sepsis is present the process of separation of the gangrenous tissue is the result of an active inflammatory process and takes place at the expense of the living tissue, which may be destroyed considerably in the process. The line of ulceration ("line of demarcation") is well marked and deepens rapidly, though this process may be masked by the skin remaining intact for the first ten or fourteen days, after which time it gives way, and allows the escape of yellowish sanious pus, revealing a groove lined with granulation tissue extending into the tissues. The inflammatory process is by no means limited to the immediate vicinity of the line of demarcation, and not infrequently severe constitutional disturbance, due to absorption of toxins, may be present in these septic cases.

VARIETIES OF GANGRENE

Apart from the two clinical types of gangrene described, it is customary to classify the various varieties of gangrene according to their ætiological factors. Many classifications are in use, but the following will be found to be simple and at the same time practical:—

1. **Gangrene symptomatic of Cardio-Vascular Disease.**
    - (A) *Thrombotic.*
        - (i.) From disease of the vessel wall.
            - (*a*) Senile.
            - (*b*) Non-Senile.
        - (ii.) From pressure without on the vessel wall.
        - (iii.) Traumatic (see below).
    - (B) *Embolic.*
    - (C) *Neuropathic.*
        - (i.) Spasmodic—Raynaud's disease.
        - (ii.) Toxic—ergot—carbolic.
        - (iii.) Bed sores—trophic ulcers.
2. **Traumatic Gangrene.**
    - (A) Direct.
    - (B) Indirect.
3. **Thermo-Chemical Gangrene.**
    - (A) Burns and scalds—heat.
    - (B) Frost-bite—cold.
    - (C) Escharotics.
4. **Infective Gangrene.**
    - (A) *Acute inflammatory*—pyogenic organisms. Carbuncle—Cancrum Oris—Noma vulvæ—Phagedæna—Spreading subcutaneous gangrene.
    - (B) *Gas Gangrene*—anaerobic organisms.
5. **Toxic Gangrene.**
    - Diabetic gangrene.

As will be seen from the above, it is impossible to give a definite ætiological classification of gangrene, as many factors contribute to the cause of several varieties of gangrene. Thus in the neuropathic varieties, infection and vascular degeneration, to both of which nerve changes render the affected part particularly liable, all play a part in determining the onset of gangrene, and similarly in traumatic gangrene, vascular thrombosis and nerve destruction greatly assist in delimiting the area of dead tissue.

(1) SYMPTOMATIC CARDIO-VASCULAR GANGRENE

(A) **Thrombotic.** (i. *a*) **Senile Gangrene.** This is by far the commonest type of gangrene met with in civil practice. It occurs in old people, usually above sixty years of age, and is the result of degenerative changes in the walls of the arteries and arterioles, usually of an arterio-sclerotic and obliterative nature, which are not infrequently syphilitic in origin (*q.v.*, p. 264); hence the blood supply is gradually cut off, and the gangrene, which usually starts in the distal ends of the limbs, usually the lower, is of the dry type. The determining factor is usually some slight trauma, frequently the too drastic trimming of a toe nail, which results perhaps in a mild infection, or perhaps is in itself sufficient to cause the diminished blood supply to be insufficient to respond to the extra calls of the feeble inflammatory reaction in the already impoverished tissues. The result is a local death of tissue which presents all the local signs of gangrene (p. 152), and which later changes from a white to a black colour.

The tissues more remote from the periphery may have sufficient vitality to react and attempt to demarcate and throw off the dead area, but this process is seldom completed, for the very inflammatory reaction entailed is too much for the blood supply to cope with, so that the thrombosis spreads, and the gangrenous area gradually extends, till the whole toe, or even the foot, is dry and dead.

Occasionally the thrombosis may occur in a much larger vessel, such as the posterior tibial, or even the popliteal, and then death of the whole foot is instantaneous, and the gangrene spreads steadily up the leg. In this type no pulsation can be felt in the vessels below the point of thrombosis, and the artery usually can be felt as a thickened hard cord throughout the limb. An X-ray film may show extensive calcification in the vessel walls. There is usually considerable pain in the affected part, especially in the early stages, and this and cramps may precede the onset of the actual gangrene by several weeks.

The constitutional signs are often severe, there being fever and toxæmia, showing itself in muttering delirium, carphology, wasting and a dry tongue; glycosuria of toxic origin is frequently present, and may lead to a diagnosis of diabetic gangrene, but the condition at once clears up when the dead tissue is removed and no other signs of diabetes are present; also the gangrene in the senile type is dry, whereas true diabetic gangrene is always moist.

Treatment. In elderly persons in whom gangrene is threatening, as is shown by coldness, cramps and a sense of weight and fatigue usually in the lower limbs, prophylactic treatment may do much to stave off the actual onset of gangrene, though it seldom permanently averts it. Such a limb should be protected from cold and trauma by wrapping in cotton wool, or warm, close-fitting woollen stockings, elevated whenever possible, and the circulation be improved by the use of faradism, massage, hot-air baths, etc. Great care must be exercised to avoid infection or injury when cutting nails or corns and in the use of hot bottles.

In this stage marked improvement may follow either (*a*) ligation of the femoral vein in Scarpa's triangle, a condition of passive congestion being thus induced, or (*b*) the injection of about 1·5 to 2 c.c. of alcohol into the femoral sheath in this situation, with the object of paralysing the sympathetic vasoconstrictor fibres and so inducing vaso-dilatation in the limb. Successful results have been recorded following the operation of periarterial sympatheticectomy in this and other forms of gangrene (see p. 384). (*c*) Arteriovenous anastomosis is sometimes carried out in Hunter's canal, but the results of this rather difficult operation are far from satisfactory. (*d*) Lumbar sympatheticectomy. These procedures all relieve pain even if they make little difference to the circulation in the limb.

Once gangrene has definitely supervened, treatment is governed by the knowledge that owing to the poor nutrition in the tissues locally, any likelihood of the gangrene being restricted is very small, and it is therefore advisable to amputate at once, so as to save the risk from constitutional disturbance in an old person.

Owing to the local conditions mentioned it is obvious that the amputation must be performed well away from the affected area, and that some method of covering the stump without long skin flaps is less likely to be followed by sloughing from inadequate blood supply. It is customary in these cases, therefore, to perform a circular cuff amputation through the lower part of the thigh, an operation which, besides being rapid, fulfils the above requirements, and has the additional advantage of being above the bifurcation of the popliteal vessel, a point where, as already pointed out, thrombosis frequently occurs. Rapid improvement usually follows the ablation of the dead area, but the other limb should be carefully protected, lest gangrene supervene there also. General anæsthesia under ether or gas and oxygen is well tolerated in these cases.

(i. *b*) **Non-senile thrombotic gangrene** is nearly always due to thromboangiitis obliterans (Buerger's disease), but may be syphilitic in origin, being the result of a chronic inflammation in the walls of the arterioles and small arteries (endarteritis obliterans) narrowing their lumina till ultimately thrombosis ensues. It rarely may occur in debilitating fevers such as typhoid, or in severe anæmias. A type due to a toxæmia of unknown origin is met with in South-East Europe, especially amongst the Jews; it is closely allied to Buerger's thromboangiitis obliterans, where extensive femoral arterial thrombosis first ensues, and later venous thrombosis follows. The resulting gangrene is extensive, frequently dry in type and often symmetrical. It is a noteworthy fact that it seems epidemic in wet seasons, especially in the autumn, after a damp harvest, and usually occurs in eaters of maize and rye bread.

This type of gangrene can be dealt with adequately by local amputation and energetic treatment of the causative disease. In cases where the cerebral vessels are affected some slight recovery of the function may follow energetic general treatment; local treatment is, of course, contra-indicated in cerebral thrombosis. It is doubtful if lumbar sympatheticectomy produces any lasting improvement in these cases, though undoubted temporary improvement takes place.

(ii.) **Gangrene due to Pressure on the Vessel Wall.** This may follow pressure from a tumour, such as a saccular aneurysm (p. 268) pressing on the vessel above or below its point of origin, or any abdominal or pelvic growth pressing on the great vessels.

Rarely a cervical rib may cause cutaneous gangrene in the fingers by pressure on the subclavian artery.

The most common cause is *tight pressure bandaging* of an injured part, and it must be remembered that though a bandage is not too tight when applied to a recently injured limb, yet further bleeding in the tissues may cause the bandage to become so tight as to cause gangrene ; this is particularly the case after fractures, and splint bandages need careful watching. For the same reason a limb always should be bandaged in the position in which it is designed to retain it. As the bandage becomes too tight there is a sense of discomfort and tightness beneath and distal to the bandage, the limb becomes swollen and blue, as the venous return becomes obstructed first, and is very painful and tender. Later it becomes numb and insensitive. In this type of case the onset of symptoms is very gradual and actual gangrene is rare.

Treatment consists in removing the source of pressure where practicable, and dealing with the gangrene should this have actually occurred. In the case of an aneurysm, a spontaneous cure may be affected thus, and the condition should be treated palliatively, as actual gangrene rarely supervenes.

(B) **Embolic Gangrene.** This is the result of a detached portion of blood clot (embolus) being carried in the blood stream, and lodging in the lumen of a blood vessel where this narrows down, so that it stops the blood flow to the part beyond. It follows that emboli are frequently arrested at the point of bifurcation of an artery, and " straddle " this, causing blockage of both branches, as is not infrequently seen at the bifurcation of the popliteal or brachial arteries, a condition which rarely may be symmetrical in occurrence.

These emboli may be derived (1) in the arterial system from (*a*) fibrinous vegetations from the cardiac valves, particularly in ulcerative endocarditis, (*b*) detached calcareous plates from the degenerated endothelium of large arteries in atheroma, or (*c*) clot detached from an " infarct " in some internal viscus ; (2) in the venous system from some septic thrombophlebitic clot, as from the uterine vessels in post-partum cases, or in thrombosed varicose veins ; and (3) in general infective conditions such as typhoid, pyæmia and septicæmia when they may be a terminal event. These pass through the heart, and usually get held up in the capillary plexus in the lungs ; however, they may get through here and become arrested in the capillaries in the other internal organs—brain, liver, spleen, kidneys, etc.—where there is but little anastomosis. The consequent gangrenous area is known as an " *infarct*," and is at first swollen and reddish in colour due to flooding of the area with blood from the back pressure ; the infarct usually becomes absorbed and replaced by scar tissue after a process of aseptic inflammatory reaction, but it may become infected, often from organisms in the infected clot itself, when a " pyæmic abscess " results (see p. 77).

Clinical Signs. The gangrene may be of the dry or moist type, and, as organisms are often present in the clot, usually becomes septic, forming a foul discoloured mass, often covered with bullæ, containing evil-smelling sanious fluid and gas.

Treatment. It must be remembered that this type of gangrene is often symptomatic of serious blood infections (Septicæmia, p. 75), and that the general signs of these serious troubles may overshadow the local signs and contra-indicate any radical local treatment.

Embolectomy. In many instances this operation may be undertaken with a fair prospect of success, but it is essentially an urgent procedure. If not performed within twelve hours of the embolus having formed it is not likely to save the limb, for this will already be becoming gangrenous and clot will be extending all down the vessel. The artery is clamped and opened, the embolus is removed and a watertight arterial suture put in the vessel wall : this is best done under a local anæsthetic. The results are better in the upper limb (60 per cent. success) than in the lower (20 per cent. success). When the embolus is in a situation difficult of access (for example, the bifurcation of the common iliac artery or the aortic bifurcation), an incision may be made in the femoral artery and a blunt instrument pushed up the vessel to loosen or break up the embolus. The stream will then wash the pieces out. If the embolus is at the aortic bifurcation the opposite femoral artery should have a temporary clamp put upon it to prevent pieces of embolus lodging in it.

If the limb is already gangrenous, as a rule the gangrenous area should be removed as soon as a line of demarcation has formed. This is urgently indicated as soon as sepsis supervenes.

(C) **Neuropathic Gangrene.** (i.) **Spasmodic—Raynaud's Disease.** The consideration of the ætiology of this interesting neuropathic condition properly belongs to a text-book of nervous diseases; suffice it here to state that the condition is the result of vaso-motor spasm in the arterioles. Recent experimental work has shown that attacks can be brought on by cooling the palm of the hand in water to 15°–18° C., and local cold applied to part of the palm of the hand makes the corresponding fingers go cold. It appears then that the condition is more due to a local spasm of the palmar arteries than to a generalised vasomotor disturbance. The vasomotor nerves to the palm of the hand run chiefly in the ulnar nerve, but if this is anæsthetised with a local anæsthetic the attacks can still go on. It is usually met with in the fingers, toes and ears of anæmic young women, and is often symmetrical, being more common in the upper extremities; there is often severe pain, and maybe paroxysmal hæmoglobinuria, but other signs are absent, apart from the local changes in the affected parts. These are usually described as falling into three stages, but not uncommonly they may be merged: (1) local syncope, the part being white, anæmic and cold; (2) local asphyxia, the part becoming blue and swollen, the blueness being due to removal of the oxygen by the tissues; and later (3) local gangrene supervening in part of the area. Usually only the skin is affected, but deeper tissues may be involved.

The condition much resembles that resulting from severe "chilblains," from which it must be diagnosed, and, indeed, a close resemblance exists in all stages to the changes met with in frost-bite (p. 63).

Treatment consists in the local protection of the affected areas, for which purpose ambrine or B. paraffin wax are very useful, and immersion in galvanic baths to allay the pain; tonics should be given with a view to improving the general health.

Active surgical interference is seldom called for, but sympatheticectomy or excision of the stellate ganglion is sometimes practised with relief (see p. 382).

(ii.) **Toxic.** (*a*) **Ergotism** is only met with in those countries where rye bread is consumed, and usually occurs in wet seasons, when rye infected with the fungus (*Claviceps purpurea*) has been used in making the bread. The gangrene may affect the face, ears or limbs, and varies very much in extent, in severe cases involving the loss of an entire limb.

The gangrene results from arteriole spasm, and is preceded by numbness and tingling in the area; it is of the dry type and should not be operated on until a line of demarcation has formed, as it is often impossible to judge of the location of this in the early stages.

(*b*) **Carbolic.** This drug, especially when employed hot as a continuous dressing on the fingers in women and children, may cause local gangrene, apparently due to arteriole spasm and subsequent thrombosis. It must be borne in mind in these cases that tight bandaging may play an important part, and indeed some surgeons regard this as the real cause in all cases. Carbolic may be present in the urine of these patients, which is then of a deep green colour.

The process is painless, and the skin has a peculiar dull leathery appearance.

(iii.) **Bedsores and Trophic Ulcers,** see pp. 148 and 248.

(2) TRAUMATIC GANGRENE

(A) **Direct.** This variety results from the direct crushing of the tissues as a result of trauma, and may be caused by :—

(i.) *Severe crushes,* in which case the whole of the tissues may be pulped and severe shock will be present. The resulting gangrene is of the moist type and frequently septic; it is more likely to occur in elderly people, where vascular changes have caused a low vitality in the tissues.

Treatment consists in immediate ablation of the affected area when it is obviously damaged beyond repair, but it should be borne in mind that the power of recovery of the tissues is often little short of miraculous, and if it seems that good function is possible it often will be worth while to adopt conservative measures. Shock and collapse will require treatment (p. 51). Should infection supervene, active treatment is advisable, and a close watch needs to be kept against infection by gas-forming organisms (*see* Gas Gangrene).

(ii.) *Continual pressure,* as from splints, or tumours, and tight bandaging or plaster, or from continuously lying on the same area, when a bedsore may result (p. 148).

(iii.) *Action of Corrosives and Heat.* Strong acids or alkalies or hot fluids will cause gangrene (see pp. 58 and 63).

(B) **Indirect** traumatic gangrene results in the part distal to the actual site of the injury, and may be due to :—

(i.) *Ligature of the main artery* of a limb—in cases where the anastomotic circulation cannot be developed sufficiently rapidly to carry on the nutrition efficiently. This occurs only after ligature of the common femoral in a healthy individual, and even in a debilitated subject is practically unknown except in the lower limb. The condition is said to be less liable to result if the veins are also ligatured. Such gangrene is usually of the dry type, and needs treatment only when it is showing definite demarcation (see p. 157).

(ii.) *Rupture of a main vessel,* with subsequent compression of the vessels from the pressure of the clot in the surrounding tissues. This type of gangrene is moist and often may be averted by operating, ligating the vessel, and turning out the clot (see p. 256).

(iii.) *Obstruction of both the artery and vein,* if suddenly occurring in a healthy limb, almost always is followed by gangrene, but this does not occur if there has been gradually increasing obstruction which has allowed the anastomotic circulation to establish itself; hence no ill results usually follow in cases of extensive operations for carcinoma or excision of aneurysms. Under this heading come such internal forms of gangrene as result from strangulation of the bowel in a hernia, torsion of testis, or gangrene of a limb distal to a tight bandage. In all these cases the pressure occludes the venous return before the arterial flow is finally cut off by the increasing lesion; hence the part is full of blood and a moist type of gangrene will result in all cases. This may or may not become septic.

Treatment consists in removal of the dead tissue once gangrene has occurred, but this is by no means rapid in onset and frequently may be averted by suitable treatment.

(3) THERMO-CHEMICAL GANGRENE

(A) *Heat and Electricity*. *See* Burns, pp. 58 and 61.

(B) *Cold*. *See* Frost-bite, p. 63.

(C) *Escharotics*. These are strong chemical substances, which are usually acids or alkalies, and produce extensive destruction and death by their actions on the tissues.

Treatment should be directed to neutralising the chemical action; thus alkalies (weak) should be used as antidotes where acids are inflicting injury, and *vice versâ*. The lesions resemble burns, are slow in healing, and often cause extensive deformity. Sloughs should be left to separate naturally.

(4) INFECTIVE GANGRENE

(A) **Inflammatory.** This type results from :—

(i.) The infection of already dead tissue with pyogenic organisms and saprophytes, and is indicated by the dead mass becoming semi-liquid, offensive in odour, and in some cases covered with bullæ containing gas and sanious fluid. There is usually marked inflammatory reaction locally in the living tissues, and constitutional signs may be severe from sapræmia. The condition is, in fact, a septic moist gangrene, and treatment consists in prompt removal of the mass of infected dead tissue.

(ii.) *Carbuncle and boil* are examples of a type of acute inflammatory gangrene occurring in living tissue.

Boil (p. 65) has already been fully discussed.

Carbuncle results from infection of the subcutaneous fat by a pyogenic organism, usually *Staphylococcus aureus*. This may occur following some slight injury or as the result of an auto-infection, especially in patients debilitated from such diseases as chronic nephritis and diabetes. The blood supply in the subcutaneous tissues is poor, and should thrombosis occur during inflammation, extensive gangrene and sloughing of fat may set in; only in very debilitated subjects does this involve muscle, but in all cases the skin over the dead area will slough following the cutting off of its blood supply from the subjacent tissues. Involvement of large veins close by may lead to spread of the infection with *pyæmia*, or in the neighbourhood of the head and neck to infection of intracranial blood sinuses with rapid onset of coma and death; thus carbuncles, especially of the face and mastoid region, call for prompt treatment. If left untreated, provided no such complications ensue, the slough will separate from the surrounding tissue and, the dead skin having given way, be extruded through the sinuses thus formed, leaving a deep ulcer, which in time will heal by a process of granulation.

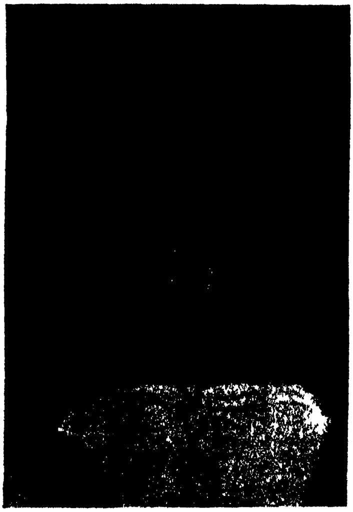


FIG. 72. Carbuncle of neck.

(*a*) The *local signs* of a carbuncle are a hard, painful swelling in the subcutaneous tissue, often on the back, the skin over which soon becomes dusky and œdematous, the colour not fading on pressure when the vessels beneath it are thrombosed. This swelling increases in size and the centre becomes soft, but rarely actually fluctuates; meantime the skin over the area becomes purplish and usually ulcerates in several spots near the centre, exposing to view the ashy slough of the subcutaneous tissue and allowing of the exit of thin sero-pus. At this stage the pain, which has been intense, is notably relieved.

Occasionally more than one carbuncle may occur in the same individual simultaneously, which renders the prognosis grave, as is also the case if the lesion is on the face, especially the upper lip.

(*b*) *Constitutional signs* are often severe, there being high fever if the reaction is good, but a normal or subnormal temperature is not infrequently present, and must be regarded with anxiety as showing poor resistance on the part of the patient. Nocturnal delirium is not uncommon, as also toxic glycosuria, which disappears when the local condition is treated.

Treatment. In those cases where *no* localisation has occurred and there is much surrounding brawny œdema, and *in all carbuncles on the face*, no active surgery is permissible, though the injection of the patient's whole blood (20–50 c.c.) at intervals around the central lesion may cause it to localise and clear up in some cases. In the early stages, where the lesion has localised, provided no thrombosis has occurred, Bier's hyperæmia and vaccine therapy may be successful in preventing actual sloughing while a local dressing of glycerin and magnesium sulphate paste gives relief. But once actual gangrene is present, and in those cases where general toxæmia persists in spite of localisation of the lesion, immediate steps should be taken to excise the dead area completely under general anæsthesia, the resulting cavity being curetted till healthy bleeding tissue is exposed, and then packed with camphenol (equal parts of pure carbolic and camphor) for twenty-four or forty-eight hours. This renders the wound and subsequent dressings quite painless, and is followed by great relief of local and general symptoms.

Subsequently, daily dressings with hydrogen peroxide (10 vols.) will cause rapid granulation in the largest cavity, and epithelialisation can be induced readily by dressings of some zinc lotion above the peroxide gauze in the cavity.

Less drastic and less satisfactory methods are to be found in the older practice of making a crucial incision in the skin to relieve tension, and leaving it and the subjacent gangrenous area to slough away, or in applying a Klapp's suction bell to assist the separation of the dead mass.

The administration of tonics, and especially port wine, does much to hasten convalescence.

FIG. 73. Cancrum oris.

(iii.) **Cancrum oris** is an infective gangrenous stomatitis occurring in young debilitated children, particularly after measles. The process, which starts as an infection from foul teeth in a mucous membrane abrasion, spreads rapidly and involves the whole thickness of the cheek, and is often accompanied by extensive necrosis of the jaw and sloughing of teeth. The whole inside of the mouth is a grey pultaceous slough, and the cheek looks dusky and later sloughs away, leaving a great hole. The tongue may be infected, and become black, and this may lead to œdema of the glottis and asphyxia. There is a very offensive discharge from the affected area, which is swallowed or dribbled from the mouth, and frequently leads to a septic inhalation, broncho-pneumonia supervening.

There is a peculiar pungent and very nauseating odour, which can be detected many feet from the patient, and usually all over the house. There is acute and severe toxæmia and the prognosis is very grave.

Treatment consists in prophylaxis by thorough mouth cleansing and care of the teeth ; these have done so much that the disease is now rarely seen. Once the condition is established, prompt excision of the entire area with curettage till bleeding tissue is reached, combined with the application of camphenol or pure carbolic, offers the best hope of a cure ; presumably chemiotherapy will be of value in limiting the spread of the infection. Should sloughing of the whole cheek take place, the subsequent deformity should be treated by plastic surgery when the infection has entirely subsided, but the results are not usually very encouraging.

(iv.) **Noma** is a similar condition occurring in the vulvæ of little girls, and is often followed by extensive cicatrisation and deformity.

Treatment is as for cancrum oris. Baths may be freely used in cleansing sloughs.

Both these conditions may occur as the result of a diphtheritic infection.

(v.) **Phagedæna,** or **hospital gangrene,** was a rapidly spreading gangrene only too often occurring in the wounds of patients in the overcrowded wards in pre-antiseptic days, and spreading rapidly from bed to bed. It is to-day practically unknown in this country, and the term *phagedæna* has come to be used in connection with the sloughing ulceration of the penis which occasionally results from neglected secondary infection in soft sores or a hard chancre, and may lead to extensive destruction of the penis.

Treatment consists in complete removal of all sloughs and the application of the actual cautery to the bleeding organ ; in less severe cases continuous antiseptic baths may suffice. The old treatment, which consisted in applying a poultice of Ricord's paste, a mixture of sulphuric acid and charcoal, is not often resorted to.

(vi.) **Spreading Subcutaneous,** or **Cutaneous Gangrene (post-operative).** This insidious and steadily spreading infection of the skin and subcutaneous fat is met with occasionally, beginning around an operation wound for some septic condition, as an appendix abscess, an empyema, or an operation on the œsophagus or upper air passages in the neck. The ætiology of the condition is not known, but culture reveals a pure culture of streptococci in nearly all cases. Possibly it is due to the presence of a streptococcal infection from within combined with a staphylococcal infection from without. Deep tension sutures may predispose to it.

Clinically. Some days after operation intense pain develops in the neighbourhood of the wound, accompanied by a dusky, purply discoloration and œdema of the surrounding tissues. Great and very distressing pain persists throughout the entire course of the illness. If untreated, the skin slowly breaks down, while the subjacent fat is found to be a mass of infiltrated purulent slough. The ulcerative condition spreads slowly but steadily, unless treated, and may involve as much as half the body surface. Apart from the intense pain and debility from loss of sleep, there is little general toxæmia present usually, though the temperature shows a hectic inclination.

Treatment must be promptly and early carried out, and consists in excising the infected area about ½ inch beyond the obvious edge of the infection, or, alternatively, in isolating it by diathermic incision down to the deep fascia. In very extensive and neglected cases this treatment may be supplemented by curettage and ionisation with zinc salts. Following excision, epithelialisation and healing occur rapidly and the pain disappears almost immediately.

(B) **Gas gangrene,** or **acute spreading gangrene,** is a very serious and fatal condition, fortunately not often met with in civil practice, where, however, it may occur after any wound to which road or garden dirt has got entry, especially if extensive tissue damage be present or infection with pyogenic organisms occur. It is occasionally seen after abdominal operations as a wound infection. This type of gangrene was particularly common in wounds in the last war, where infection of tissues, much disintegrated by the concussion of a high-velocity projectile, resulted from the anaerobic and aerobic organisms in a richly cultivated soil. The cases seen so far this war are less numerous and less virulent.

This type of gangrene is always due to infection with spore-forming anaerobic bacilli of various types: (1) sugar-splitting, including *Bacillus perfringens* (*welchii*); (2) proteolytic, including *B. sporogenes, aerogenes capsulatus* and *Œdematus maligni*, which are found in soil, especially if cultivated and manured; they are normal inhabitants of the intestines and capable of very rapid multiplication under favourable conditions, such as in the depth of a wound; more especially is this so if aerobic pyogenic organisms are present in the tissues. Under unfavourable conditions they can form highly refractile and resistant endospores, which are capable of surviving prolonged boiling, and later develop when conditions become favourable, *i.e.*, in the absence of oxygen.

Owing to the large amount of glycogen present in muscle, this tissue, especially if damaged, is particularly favourable for the development of this type of gangrene; indeed, many observers consider gas gangrene always starts in the muscles of a limb, and certainly it extends more rapidly and extensively in muscle than in any other tissue, but it does undoubtedly sometimes start in cellular tissue. Where a muscle is affected, the gas spreads rapidly throughout the whole group of muscles, but frequently may be localised to the one muscle in the early stages; this is particularly the case where the blood supply of the affected muscle is impaired while that of surrounding muscles is intact.

The changes in colour of the affected muscle are very constant, the healthy red appearance vanishes, and the muscle looks swollen, puffy and dull in colour; gas may be seen among the fibres. The colour now rapidly changes to green, and then to brown and black, the muscle in this stage being disintegrated, deliquescent, and reduced to a structureless frothy slime with a most offensive fœtid odour.

The gas produced is odourless in the early stages, and consists of CO_2 and H_2 and is frequently inflammable; later it becomes highly offensive owing to the production of H_2S and indols from the proteolytic action of the *B. sporogenes* and its allies.

The *local clinical signs* indicative of the onset of gas gangrene may be noticed very shortly after infliction of the wound, although in some cases their onset is delayed for some days. The wound usually looks unhealthy and the edges are often white and pouting, though the surrounding skin soon assumes a dusky hue, and later becomes swollen with gas. There is a brownish watery discharge, which may be very free and often contains bubbles of gas; odourless at first, it later has a foul and very fœtid odour, which can be detected at some distance from the patient. The affected area is swollen and tympanitic to percussion, while crepitation can be detected in the tissues due to the presence of the gas, which spreads along any invaded muscle far beyond the limits of the wound. Should much gas be present, an X-ray film will show the affected muscle or muscles to be much clearer than normally, and to have a foamy appearance with clear spaces in them; but no time should be wasted in X-ray diagnosis.

The *general signs* will be modified according to the type of gangrene, *i.e.*, whether (1) localised, (2) restricted to one group of muscles, (3) generalised in the affected limb—the so-called "massive" type—or (4) fulminating.

1. *Localised Type.* The signs of general infection are slight, there being a raised temperature, often accompanied by rigors and vomiting. The gas remains localised to the area of the wound, and a fatal result is averted by prompt treatment.

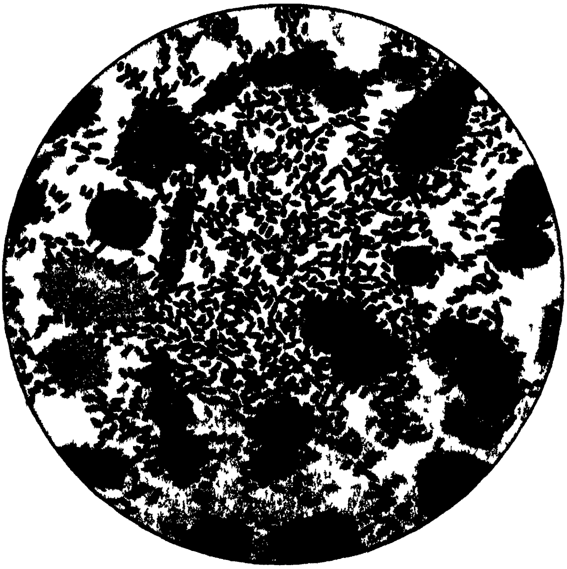


FIG. 74. *B. welchii* in liver (× 650). Note separation of liver cells due to gas.

2. *Group Type.* The general signs of toxæmia are much more severe, delirium is often present, and the patient suffers acute pain in the limb, the muscles affected being swollen and tender and frequently sloughing through the discoloured skin.

3. *Massive Type.* This is always associated with serious injury to the main vessels of the limb, and may occur in a limb already dead from this cause, in which case the general signs are usually mild. In the acute primary variety constitutional disturbance is severe, and often there is a rapid pulse with a normal or subnormal temperature, a sign of very grave import. The patient is so pale as to suggest that severe hæmorrhage is still occurring, but there is profuse sweating and great restlessness, with *no* air hunger.

4. *Fulminating Type.* In this rapidly fatal condition the gangrene spreads

with alarming rapidity, and the whole body may be converted into a putrescent gaseous mass in a few hours. The mental condition usually remains clear and death occurs rapidly and very suddenly. The tongue is brown and dry, the facies drawn and pale, the pulse rapid and irregular, the temperature subnormal, and vomiting marked.

The *differential diagnosis* of the condition from other types of **surgical emphysema** which may be met with is usually easy, as in these no toxic signs are present, though it must be borne in mind that the trauma preceding the emphysema may cause considerable shock in the patient. Surgical emphysema other than from infection with gas-forming organisms is limited to the regions of the gas-containing viscera in the body, though in the later stages it may spread widely.

It will not perhaps be out of place at this stage to enumerate the situations in which surgical emphysema may be met with, and briefly discuss the causes of the condition.

1. Around the face, from injury to the nasal passages and accessory sinuses. In this respect it may be noted that surgical emphysema is sometimes met with over the mastoid region in lesions involving the antrum and cells.

FIG. 75. Gas gangrene, showing swelling and discoloration of the abdomen and thighs.

2. In the neck, following injuries to the trachea and larynx, and after tracheotomy.

3. In the mediastina, after injuries to the region of the root of the lungs; there is usually dyspnœa, and later crepitus at the root of the neck. An X-ray film shows gas in the thorax in these cases.

4. Around the chest wall, following injuries to the lungs (Chapter XI., Vol. II.).

5. In the flanks and down the thighs, following injury to or ulceration through extra-peritoneal portions of the intestinal tract, usually the colon, as from extra-peritoneal perforations of a malignant ulcer. This form is partly due to gas-forming intestinal organisms and is similar to gas gangrene in all respects. It is usually fatal (Fig. 75).

6. On the chest and abdominal parietes, where very rarely respiratory movements may suck air into a valvular wound.

7. It must be borne in mind that if any wound is treated with hydrogen peroxide, the gas liberated on its contact with damaged tissue will penetrate for some distance into the cellular tissue and give rise to crepitus. Care must be taken not to mistake this for gas due to the presence of organisms. The patient shows no general signs of toxæmia and the gas disappears in a few hours.

Treatment consists in the immediate and free removal of all infected tissues, especial attention being directed to the muscles, which may need to be entirely excised. The wound should be left open and exposed to the air and dressed with, or, better, irrigated with, hydrogen peroxide or some strong antiseptic such as Dakin's solution. Secondary suture can be performed later, when the infection has been overcome. The injection of hydrogen peroxide into the tissues around the infected area is undoubtedly of value in limiting the spread of the infection after treatment of the gangrenous area.

In the "local" type excision and free incisions may be tried, with entire removal of the infected muscles.

Amputation of the affected limb proximal to the gas-containing region is frequently necessary in the "group," and always in the "massive" types; bearing in mind that the gas has spread far up along infected muscles, it should be performed well clear of the gas area, and always must be of the circular type, and usually by the circular cuff method, sewing the skin back. The administration of *B. welchii* serum always should be undertaken, while good results are reported from chemiotherapy by sulphanilamide which certainly clears up any superadded septic infection.

In the "fulminating" type local treatment should be attempted only if the gas is sufficiently localised for there to be any reasonable hope of dealing with the infected area, and even in these cases the chances of averting death are small.

Prophylaxis, as will be appreciated from the foregoing paragraphs, is more likely to be successful than attempts at cure. Therefore:—

1. Every care should be taken very carefully to excise as early as possible all wounds in which road dirt or soil is likely to be incorporated, and *B. welchii* antitoxic serum given, usually a dose of 40 c.c. intramuscularly.
2. Avoid anything likely to impair the blood supply to the damaged area, such as tourniquets, tight bandaging or splints.
3. Never plug tightly or use antiseptic pastes, as these preclude aeration, and for the same reason dressings should be changed frequently.
4. Should suppuration occur, irrigate continuously with Carrel Dakin tubes, as the pyogenic organisms are aerobic and their presence favours the growth of anaerobes (see also p. 33).

(5) TOXIC GANGRENE

Diabetic Gangrene. That due to Diabetes mellitus is usually a senile gangrene, exhibiting certain differences due to the presence of sugar in the blood and tissues. Care must be taken in this respect to discriminate between those cases of senile gangrene with a secondary toxic glycosuria and true diabetic gangrene.

Diabetic gangrene is practically unknown in young persons with diabetes, and is probably therefore largely due primarily to the arterial degenerative changes of old age, though the condition of the tissues in diabetes undoubtedly favours the progress of the gangrenous process once this has been established by any slight trauma. The gangrene usually starts in the lower extremity below the knee and rapidly becomes "moist" in type. It is this which distinguishes it from senile gangrene with glycosuria, which remains "dry."

Clinically the gangrene is of the septic moist type and usually spreads rapidly, with extensive sloughing of the skin. There is usually great pain, partly due to co-existing diabetic neuritis. There is marked inflammation in the adjacent living tissues, but it is seldom that a definite line of demarcation is formed. Other signs of diabetes, such as eye changes, are frequently present. Acetone is often detected in the breath and urine, and death in coma may occur not infrequently.

Treatment consists in early amputation of the gangrenous limb as in senile gangrene, a general anæsthetic being usually well tolerated. The general condition of the patient needs careful attention, but insulin gives very disappointing results in these cases of gangrene, though improvement in the local condition follows its administration.

CHAPTER VIII

TUMOURS AND CYSTS

The term " tumour " is often loosely applied to any swelling met with in the body whatever be its cause or nature, but it should be restricted rigidly to growths of new formation in the tissues (neoplasms), and never be applied to inflammatory or traumatic swellings, or simple hyperplasia of tissue. It is very difficult to obtain a clear definition of a tumour, but perhaps it may be best defined as " a new tissue formation, starting in the parent tissue from no known cause, and developing independently of the growth and nutrition of the parent tissue, but at the same time fulfilling no useful purpose nor any physiological function, except in the case of the ductless glands."

By this definition inflammatory reactions, which tend to elimination of irritants and to tissue repair, hypertrophies called forth by physiological needs, and exaggerated development of a portion of a limb, such as is seen in " gigantism," are all excluded from the realm of tumours.

Origin and Causation of Tumours. But little is known as to the origin and causation of tumours in the tissues, although much work has been done and is now being done on this subject, especially in regard to tumours of the malignant type. Certain facts are, however, well recognised in regard to tumours; although in most cases many different theories have been enunciated to explain these facts, the cause of which is at present unknown, they are herewith briefly enumerated :—

1. No one knows exactly what determines the commencement of a tumour or new formation in any tissue, but it is generally acknowledged that long-existing *chronic irritation* is a powerful predisposing cause. This may be mechanical, as in the case of an occupational skin tumour as met with on the scrotum and arms of tar workers, or may result from the friction of a clay pipe or jagged tooth on the lip or tongue ; or it may be bacterial, as is seen in the tumours arising in chronically infected breasts and gall-bladders. Whether the irritation (*a*) starts up the growth of islets of undifferentiated fœtal tissue, as suggested by Cohnheim and Virchow, or whether (*b*) it determines some disturbance of tissue tension probably due to the absence from the tissues of some substance essential in normal cell metabolism, such as vitamins or allied bodies, and so upsets cell growth balance, are not subjects relevant to a surgical text-book, and for a discussion on these matters the reader is referred to a book on pathology ; there also he will find a discussion of the theory that (*c*) tumours may be of parasitic origin, though if this be the case, it should be expected that all tumours would be of a granulomatous, *i.e.*, connective tissue type, on analogy with the lesions produced by other parasites. (*d*) Other observers consider that lymph stasis in the tissues plays an important part in the causation of tumours, comparable, possibly, to the tissue over-growth seen in elephantiasis.

The researches of Gye would appear to have established that :—

(*a*) Some malignant new growths contain an ultra-microscopic virus that can be cultivated.

(*b*) That this virus alone does not produce a tumour, but that when injected with virus-free extracts of tumour cells (the specific factor) a malignant neoplasm is produced, the virus then being able to attack the host's cells and convert them into cancer cells.

(*c*) That although the specific factor only functions in animals of the same species as that from which the tumour is obtained, the virus is non-specific, and will produce a malignant neoplasm with the specific factor of any given species in that species.

These conclusions are, however, not universally accepted at present.

2. Whichever of these three theories, if any, be correct, it should be noted that the new formation of tissue always breeds true to type ; thus a tumour starting in connective tissue will always consist of connective tissue, whereas one growing in epithelium will not only be an epithelial tumour, but will faithfully reproduce the type of epithelium in which it grows ; moreover, in the case of malignant tumours, where secondary growths are found about the body, these metastases are always of the same structure as the parent tumour, although they may be found among any type of body tissue.

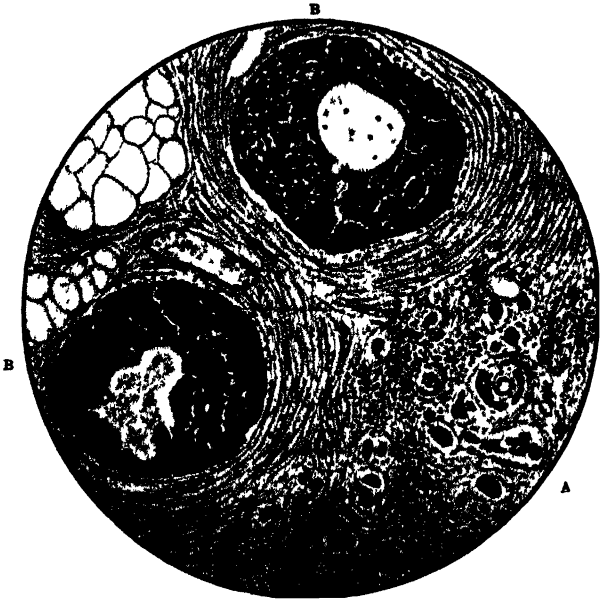


Fig. 76. Breast showing : A, carcinoma ; B B, acini with great epithelial hypertrophy, probably a pre-cancerous stage (× 65).

In this relation it must be remembered that, especially in rapidly growing tumours of the malignant type, the cells met with are frequently ill-differentiated and embryonic in appearance, and so may not be immediately recognised as being connected with the parent tissue in which the tumour started.

In this connection it should be noted that if columnar-celled epithelium is exposed to chronic irritation, as in prolapsed piles or an infected antrum of Highmore, it will become stratified and change into squamous epithelium, and thus squamous-celled carcinoma may occur in situations normally covered with columnar epithelium if long-standing irritation has, as is often the case, preceded the onset of the malignant changes.

3. When such a tumour has developed in a tissue, one of two results may

occur, according perhaps to the tissue reaction, or perhaps to the amount of disturbance of cell metabolism in the tumour :—

(*a*) The new growth may be limited to the tissue in which it originates, although it may exceed this vastly in size, and so displace and distort other tissues; in which case the neoplasm is entirely surrounded and limited by a *fibrous true capsule* containing no tumour elements, which is derived from the surrounding tissue reaction, and sharply defines the new growth; such is a **Simple or Benign Tumour.**

(*b*) On the other hand, the cells of the new growth may not be so limited, and, in addition, may pass through the basement membranes bounding the parent tissue and invade the surrounding tissues which they subsequently destroy and replace, and which are then said to be "infiltrated by the new growth." Such a tumour has no capsule, nor are its edges well defined or limited by tissue reaction, though this may be successful in some parts of the growing margin in stemming the invasion, and forming a partial fibrous barrier (false capsule) in that region, among the cells of which, however, cells of the neoplasm can always be found. Such is a **Malignant Tumour,** which may be merely *locally malignant*, or more commonly become distributed all about the body following on the invasion of the blood and lymph vessels by the cells of the tumour, which are carried in the stream or rapidly grow along the lumina of the vessels, to distant parts; these scattered cells continue to grow, forming *Metastases*, or secondary deposits of the original or primary growth.

4. It is known that such tumours, whether simple or malignant, vary much in their rate of growth, not only in different individuals, but also at different times in the same individual, though little is understood as to the causes that influence these changes in development. Moreover, it is a well-known fact that such a tumour may shrink gradually and apparently entirely disappear, thus effecting a spontaneous cure, though such a happy result is unfortunately very rarely seen; more usually after a period of remission the growth again manifests itself in the tissues of the host.

5. Heredity may play a part in predisposing the tissues to become the seat of a neoplasm in successive generations, but there is nothing to prove that the neoplasms themselves are transmitted directly from one generation to the next.

The question of the *possibility of communicating malignant tumours* from one person to another is one which is of great interest to the public, and about which every medical man is sure to be asked sooner or later. Much evidence has been collected in the matter, but no very definite results achieved.

It is an established fact that carcinoma can be implanted from one mouse to another of its species, and that this process can be repeated almost indefinitely and with greater ease at each subsequent inoculation. Moreover, in some such cases where the primary carcinoma graft is destroyed by the tissues of the host, a malignant connective tissue tumour (sarcoma) may develop at this spot, probably as a result of the irritation set up by the foreign tissue.

Two interesting points have been discovered in relation to these experiments :—

(*a*) Only the epithelium of the graft lives and grows, the stroma degenerating and disappearing.

(*b*) In cases where the graft is destroyed by the tissues of the host, he is immune against all subsequent inoculations by carcinoma graft.

Such cases are known in man, but although there are some few well-authenticated instances of the transposition of carcinoma from one part of the body to another in the same individual, as in the case reported by Butlin of a man with a carcinoma of lip, who had the habit of scratching his lip and then his nose, and subsequently developed a growth in the latter position, only one authenticated instance has been reported of the implantation of carcinoma from one individual to another.

It is certain, therefore, that malignant tumours are not usually contagious from one individual to another, although it is within the experience of most surgeons that malignant cells may be implanted in operation wounds in the same patient and frequently give rise to tumours there.

There is little or no evidence that " cancer " districts and houses are really existent, though there is some evidence in support of the more frequent occurrence of malignant disease in damp low-lying country, and there is no doubt it is more frequent among the dwellers of towns, especially where overcrowding exists. It is more probable in these cases that there is in the food supply in the district or family concerned a persistent absence of some essential factor in food such, perhaps, as vitamins, which, while not visibly affecting nutrition, yet causes disturbance in cell metabolism, and so permits of abnormal tissue growth.

The age incidence of tumours is of interest, but not helpful in eliciting their cause; the epithelial tumours (especially if malignant) are commonly met with in the later years of life, whereas connective tissue neoplasms occur more frequently in young persons. The resistance of the normal tissues to the growth of the neoplasm is much greater in the old than in the young, and moreover, may vary considerably both in patients of the same age to the same type of tumour, and to various varieties of new growth. *Both sexes* are apparently equally liable to be the host for any tumour, though certain regions are more frequently affected in each sex; thus in man the tongue, œsophagus, stomach and rectum are particularly prone to carcinoma, whereas in woman, in whom these situations are rarely the site of a new growth. the uterus and breast are frequently affected.

Clinical Examination. Before proceeding to any attempt to classify or describe the various types of tumours met with in the human body, it will be of advantage briefly to discuss the clinical history of such cases, and to indicate the chief points in the examination of tumours, with especial reference to arriving at a determination as to whether a particular neoplasm is simple or malignant.

Whenever a case of new growth is presented for examination, and irrespective of its situation in the body, the following points must be observed carefully :—

1. It must be determined, if possible, in what tissue the neoplasm originates and if it is limited to that tissue.

2. The size and shape of the tumour must be ascertained.

3. It must be discovered if the tumour is fixed to surrounding structures, with especial reference to—

(*a*) The skin.

(*b*) The deeper structures, such as muscle and bone.

4. It must be carefully noted if the edge of the tumour is distinct or fades imperceptibly into the surrounding tissues, which are probably thickened. (This, as also fixation, is strongly suspicious of a malignant tumour, but it must be borne in mind that they occur in any inflammation, and the

diagnosis between these two conditions is not infrequently one of the hardest problems a surgeon is called upon to decide.)

5. The consistence of the tumour, whether solid or fluid. In this respect remember (*a*) that translucency should be tried for, (*b*) that fluctuation can be obtained across a muscle, but not in the direction of its fibres. This may vary in different parts of the same tumour, should, as is often the case, cysts be present due to retention or degeneration.

6. The condition of the surface of the tumour, whether smooth or lobulated, is of importance.

7. A careful general examination of the body, especially the nearest lymph nodes and the lungs, must be made, with a view to ascertaining the presence of metastases.

Careful attention to the above points almost always will solve the question as to the simple or malignant nature of the tumour ; thus a defined tumour limited to one tissue and with no metastases is probably simple, whereas a tumour with edges passing indefinitely into all surrounding tissues, fixed, and showing metastases elsewhere in the body is undoubtedly malignant.

In the case of *simple tumours* the subsequent history is one of local growth, the tumour only being dangerous to life from its size causing pressure on vital structures ; such tumours, however, rarely may undergo malignant changes, and it is, therefore, well to advise their removal.

Malignant tumours vary very much, both in their rate of local growth and dissemination, but they are always ultimately fatal, the average duration of life being from three to six months in the case of sarcoma, and from two to three years in the case of carcinoma, whether the condition be treated or not ; but wide variations are met with in individual cases, and the prognosis always should be guarded. Operation should be urged in all early cases, and strongly advised in those later ones where the primary growth is likely to ulcerate.

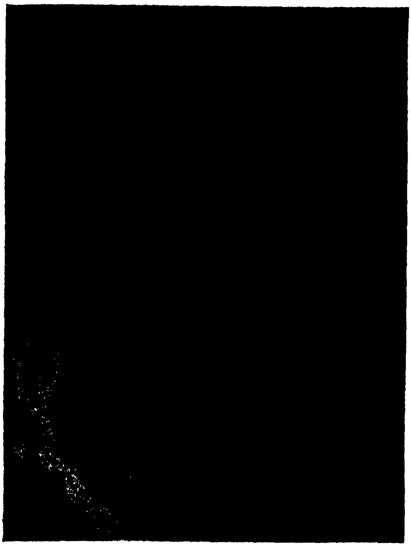


FIG. 77. Ulcerating carcinoma, showing heaped-up edge and skin attachment.

Treatment in both classes should consist in removal, an easy matter in the case of simple tumours, if not too large. In the case of malignant tumours the ideal operation consists in removal of the tumour, the tissues in which it is situated, and its metastases in one mass, an operation which, owing to its magnitude and the bulk of tissues involved, is seldom feasible ; but where this is impossible many surgeons prefer to use radium or deep X-rays, either *per se* or combined with local surgical removal of the tumour. In inoperable cases X-ray and deep ray therapy, radium, and ultra-violet ray treatment should be tried, or injections of lead and other salts and metals, lipoids, etc., with the object of affecting cell metabolism, but it cannot be claimed that any of these methods has had markedly successful results.

There are *three popular fallacies* as regards tumours, and particularly malignant neoplasms, which are classed as cancers, which it is very necessary to combat energetically. They are :—

1. That the growth is of necessity painful, which it is not unless nerves are pressed on or invaded.
2. That the tumour if malignant must grow rapidly ; this is frequently not so.
3. That the growth is attended by rapid loss of weight and health ; here again it is well known that the cancerous cachexia depends not on the presence of the tumour, but either on its situation causing obstruction to the ingress of food, or a secondary infection having occurred in a malignant ulcer.

Classification of Tumours. Many classifications of tumours based on either (*a*) their structure, (*b*) their origin, or (*c*) their mode of growth have been attempted, but in view of the slight knowledge possessed in these matters, none can be considered satisfactory, and for purposes of this text-book it is proposed merely to divide the tumours into :—

1. Those arising in the epithelium of the skin, mucous membranes and glands of the body.
2. Those arising in the various connective tissues of the body.
3. Tumours containing both kinds of tissue.

1. **Tumours arising in epithelium,** *i.e.*, skin, mucous linings of the intestinal tract, pulmonary and urinary tracts, epithelium of ducts and glands.

These may be—

(*a*) **Simple.**

		Commencing in
(i.) Papilloma		Skin, mucosa of mouth, œsophagus, anus, vocal cords, bladder and urethra,
	(*a*) Squamous-celled	
(ii.) Adenoma	(*b*) Columnar-celled	uteri.
(*b*) **Malignant.**	(*c*) Spheroidal-celled	*b* { Intestinal tract, respiratory tract, body of uterus, ducts of glands.
(i.) Carcinoma		*c* { Secreting epithelium of glands.

(ii.) Hypernephroma.
(iii.) Adamantinoma, found in the pituitary region.
(iv.) Melanoma (melanotic cancer).

2. **Tumours arising in connective tissues,** *e.g.*, subcutaneous fascia, connective tissue, bones, muscles, nervous structures, vessels.

(*a*) **Simple.**

(i.) Lipoma.	
(ii.) Fibroma.	The tissue cells in these tumours
(iii.) Myoma.	are well differentiated and of the
(iv.) Myxoma.	adult type.
(v.) Glioma.	
(vi.) Neuroma.	Frequently two or more varieties
(vii.) Chondroma.	coexist in the same tumour, *i.e.*,
(viii.) Osteoma.	fibro-lipoma ; osteo-chondroma,
(ix.) Odontoma.	etc.
(x.) Angioma. }	(*a*) Hæmangioma. (*b*) Lymphangioma.

(*b*) **Malignant.**

(A) *Locally:*

(i.) Endothelioma (ii.) Myeloma (osteoclastoma).	The tissue cells are often ill differentiated and of an embryonic type.

(B) *Generally:*

Sarcoma.	1. Round-celled. Chloroma.
	2. Spindle-celled.
	3. Giant or mixed celled.

3. **Tumours containing both epithelial and connective tissues,** and being apparently of embryonic origin.

(*a*) Teratoma.

EPITHELIAL TUMOURS

These are tumours composed mainly of epithelial cells, but usually having a core of connective tissue, and always reproducing the type of epithelium in which they originate—squamous, columnar, or spheroidal; it must be understood clearly that a neoplasm starting in a given type of epithelium cannot be of any other type of cell than that found in the tissue in which it commences.

(*a*) SIMPLE

(1) PAPILLOMA

This type of growth is primarily the result of overgrowth of the papillæ found in epithelium of epidermal origin (skin, mouth, anus, vulva and penis), when the growth consists of many layers of squamous epithelial cells, which may undergo keratinisation, with a thin mesodermal core of vessels and connective tissues. Such tumours project from the body surface, and if simple never pass the basement membrane to invade the deeper structures.

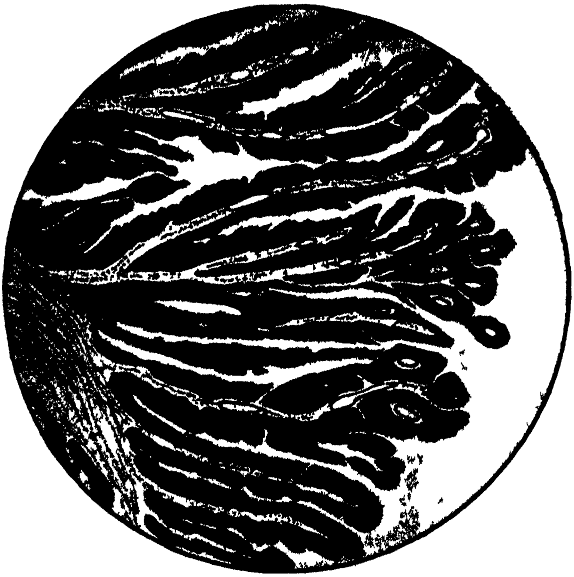


FIG. 78. Papilloma of bladder (× 25).

In old-standing cases the tumour may undergo malignant changes, which are first manifested at the base, where the cells invade the underlying tissues and form a carcinoma. The term Papilloma, however, is usually applied to any projecting growth with a covering of epithelium, and is thus used in connection with overgrowth of the other types of epithelium.

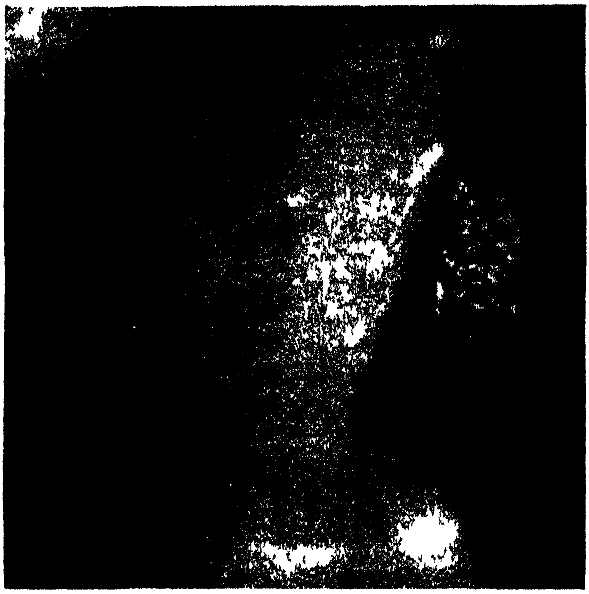


FIG. 79. Large papilloma of back.

(*a*) **Squamous papillomata,** or true papillomata, occur, as already pointed out, in those tissues arising from the epiderm of the fœtus, but a type of squamous papilloma is also met with arising from the *transitional* epithelium of the bladder (Vol. II., Chapter XX.).

When arising in connection with the skin they are usually known as **Warts, Moles or Corns,** and consist of masses of proliferated papillæ, the whole presenting a cauliflower-like appearance both on the surface and on section; in dry situations there may be keratinisation of the superficial epithelial layers, which may be so excessive as horn, and so earn such tumours the name of "horny papillomata." In moist situations the surface epithelium is usually white, sodden and desquamating, forming the so-called "soft corn."

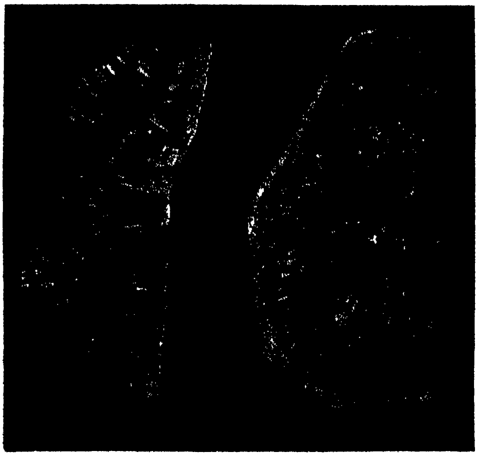


FIG. 80. Keratinisation in a horny papilloma removed from the dorsum of the hand.

It must be remembered that many papilliferous out-growths are not true tumours, but merely the result of irritation and overgrowth of papillæ from infection, as condylomata, venereal warts, etc., and, indeed, some authorities class the vast majority of cases of warts as coming under this heading, a conclusion often justified by the undoubtedly contagious properties of such warty growths.

(*b*) **Columnar-celled papillomata** are met with projecting into the ducts of the breast, and also in certain types of ovarian cyst and the renal pelvis. The so-called papillomata in the intestine are usually pedunculated adenomata.

(*c*) **Spheroidal-celled papillomata** may occur in the dilated acini of any gland, and are seen in the proliferating epithelium filling up the cystic spaces in cystadenoma of the breast.

(2) ADENOMA

This tumour consists in a more or less perfect reproduction of the alveolar spaces and secreting epithelium of glands and, therefore, may be either columnar- or spheroidal-celled in type, according as it arises (*a*) in a simple tubular gland, the secreting epithelium of which is columnar in type, as met with in the intestine, or (*b*) in a racemose gland, where the secreting epithelium is cuboidal or spheroidal, as occurs in the thyroid, breast, etc.

Such tumours, which may be single or multiple, are surrounded by a true capsule, frequently connected to the mother gland only by a thin fibrous pedicle, and consist of masses of epithelium-lined spaces, lying in a stroma of connective tissue, but not producing the secretion of the gland nor presenting any sign of duct formation; the alveoli are often quite obliterated by masses of epithelium, but it should be remembered that not infrequently they are much distended, forming cystic spaces of varying sizes in the growth, and so earning such a tumour the name of **cystic adenoma,** a condition often seen in thyroid tumours, where hæmorrhage often occurs into the cystic spaces; and that, moreover, the epithelium lining these spaces frequently proliferates, and may block the alveolus completely, such a tumour being a **papilliferous cyst-adenoma,** both of these conditions being met with in tumours of the breast and ovary.

It is often very difficult to determine if an adenomatous tumour is simple or malignant (carcinoma), as the glandular structure is very faithfully reproduced in some adeno-carcinomata and no definite diagnosis can be made unless the section passes through the periphery; then if the tumour be simple there is a definite limiting capsule, whereas in malignant cases the glandular structures can be seen invading surrounding tissues.

Certain inflammatory hyperplasias have been given the name of adenomata, although they are in no sense neoplasms; such is the so-called diffuse sebaceous adenoma met with on the nose in rhinophyma, where the blocked and dilated sebaceous glands consequent on periglandular inflammatory fibrosis form a prominent feature in any section through the thickened integument; while, again, it is very doubtful if the prostatic enlargement so frequently met with in old men is a true adenoma, or a glandular overgrowth secondary to chronic infection of the gland epithelium. Probably many of the so-called adenomata of the thyroid result from degenerative changes in the gland consequent on a local hyperplasia.

Inasmuch as the microscopic appearances of the numerous varieties of adenomata are dependent on the type of epithelium in which they commence, and their naked-eye appearances vary greatly with the gland in which they are situate, a brief description of the several types is given below :—

(i.) **Columnar-celled adenomata** occur in the glands of the skin, intestinal tract, uterus, ovary, and in infants in the stump of the umbilical cord.

Adenomata of sebaceous glands (adenoma sebaceum) are rare, although some pathologists hold that many sebaceous cysts are really tumours of new formation, and not due to distension of a blocked gland.

They are met with rarely on the labium majus or on the scalp, where they consist of a small nodular tumour, red in colour, attached to the skin, and showing small cystic spaces on section. Microscopically, they consist of masses of racemose glands lined with columnar epithelium. Similar tumours probably occur very rarely in connection with sweat glands and hair follicles.

In the *intestinal tract* adenomata may arise in connection with the glands of the mucosa of the stomach, small and large intestine and rectum, usually forming a red, easily-bleeding, polypoid mass which projects into the lumen of the bowel, being often attached to the wall only by a thin stalk containing vascular tissues and then forming a "polyp." Such tumours if present in the intestine frequently give rise to intussusception, and are found at the head of the intussusceptum, or if in the rectum give rise to severe hæmorrhage, and may be protruded through the anal canal simulating hæmorrhoids on a superficial examination. Such tumours if below the duodenum arise in connection with Lieberkuhn's follicles, and present the appearance of masses of test-tube-like, columnar-cell-lined spaces, which may undergo colloid degeneration. In examining sections of such tumours it is essential that the attachment to the muscular wall be examined carefully for signs of any invasion of the tissues by the glandular growth, as the malignant adenocarcinoma can be distinguished from the benign adenoma only by this means.

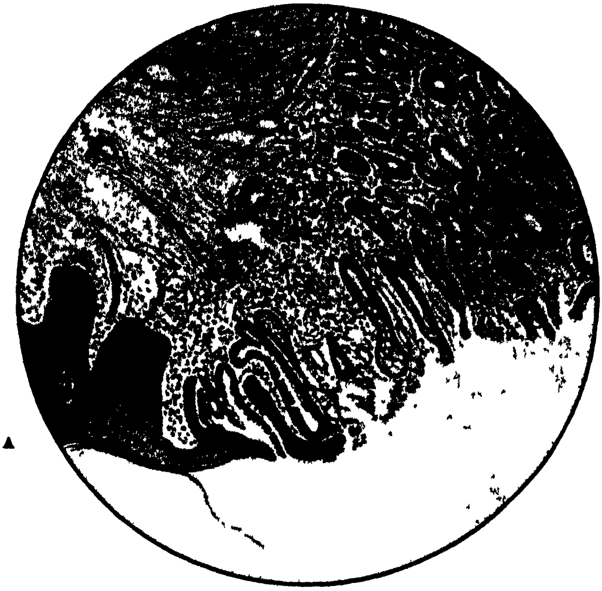


FIG. 81. Umbilical polyp (× 40).
A. Normal skin ; B. Adenoma.

In the *uterine mucosa* adenomata not infrequently occur, forming red pedunculated masses projecting into the cavity, and often extruded through the cervical canal, forming one variety of uterine polyp. Such tumours consist of many tubular glands lined with columnar epithelium, and, as in the case of intestinal neoplasms of a similar nature, great care must be exercised in discriminating between adenoma and adeno-carcinoma. Another type of adenoma occurs in connection with the deeper portions of the glands which abut on the muscle coat, and the resulting tumour is called an adenomyoma, and tends to spread into the wall of the uterus, being in some cases poorly encapsuled and apparently locally malignant.

True adenoma of the ovary is uncommon, and when present consists of a solid mass of columnar-celled tubules, but the *cyst-adenoma* arising in connection with Pflüger's tubules is met with frequently, and may reach an enormous size. This tumour, also known as a multilocular ovarian cyst, usually consists of a single large cyst, which may contain several gallons of fluid ; at one part of its inner wall is situated a mass of smaller cysts and solid areas, the whole being lined with a characteristic palisade columnar epithelium. Not infrequently these cysts may present great epithelial proliferation, forming a papilliferous cyst, and it is of interest to note that if these ovarian cysts rupture, in some instances the papillæ or mucin cells may become implanted about the peritoneum and grow rapidly for a time, though they usually undergo spontaneous retrogression.

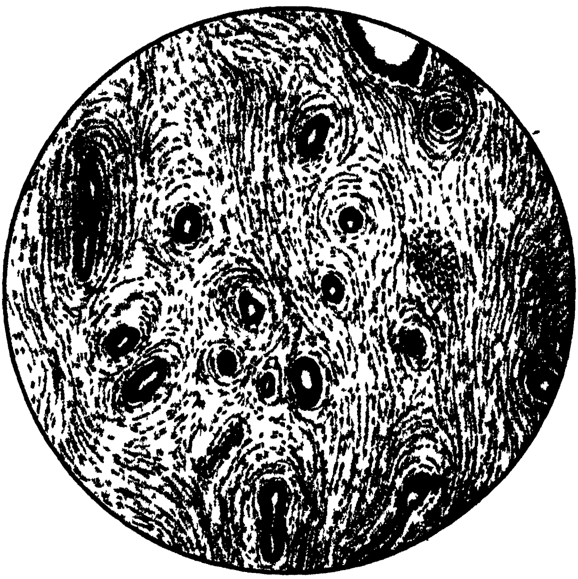


FIG. 82. Fibro-adenoma of breast (× 65).

Umbilical adenomata are small raspberry-like tumours, sometimes seen in the umbilical cicatrix of infants, consisting of masses of tubular glands embedded in a mass of mesodermal tissue, and arising in connection with the yolk sac or allantois. These are often not seen unless the lips of the umbilicus are everted, but should be suspected in any case where a persistent serous or sanious discharge occurs ; they are easily removed after ligature of the pedicle.

Rarely adenomata in connection with the post-anal gut (neurenteric canal) are met with in the anococcygeal region.

(ii.) **Spheroidal-celled adenomata** may occur in the secreting epithelium of any racemose glands, but are most commonly met with in connection with the breast, thyroid and prostate, though they may occur in connection with the adrenal, pituitary, kidney or any other gland. It will suffice here to give a brief description of the tumours met with in the common situations only.

Adenomata of the breast may be single or multiple, and usually commence between the ages of eighteen and twenty-five years; they are practically unknown in the male breast, they grow slowly, and if left untreated may reach an enormous size; more usually they become cystic, but occasionally remain solid in type, in which case they contain a large amount of mesodermal fibrous tissue in their bulk.

These tumours appear to arise often in outlying lobules of the breast, with which they have little connection, and so they present freely movable encapsuled tumours which are easily removable; should they reach a large size the breast tissue may be displaced or flattened.

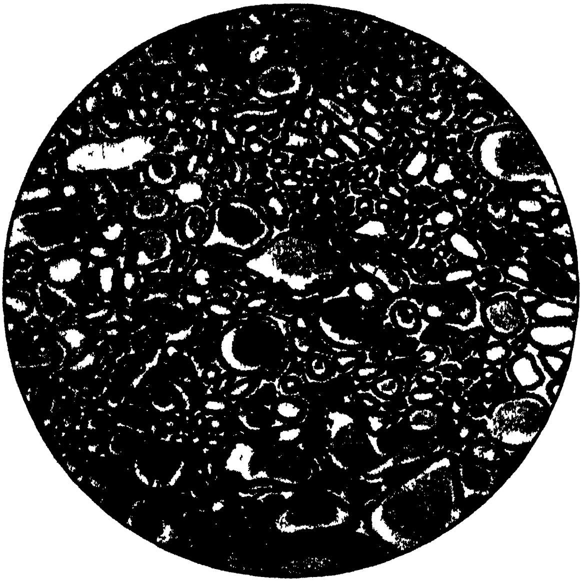


FIG. 83. Adenoma of thyroid (× 100). Note colloid in spaces.

The common type of adenoma is the *hard fibro-adenoma*, wherein is seen a mass of fibrous tissue among which lie scattered alveoli, often much distorted or flattened and lined with spheroidal cells; in some cases very little adenomatous tissue is present, and in others it may be the predominant feature, in this case consisting of masses of proliferating spheroidal-celled epithelium projecting into dilated cystic acini, the whole presenting on section an appearance very similar to that seen on the surface of a cut cabbage and forming a *cyst-adenoma*. The fibrous stroma may be soft and vascular, in which case the tumour is known as a *soft fibro-adenoma*, or very rarely it may be almost absent, when a true adenoma results consisting of columns of spheroidal cells with a few ill-formed acini.

Adenomata are frequently met with *in the prostate* of males over the age of fifty-five, and are always of the fibro-adenomatous type, either hard or soft in consistency, and usually definitely encapsuled, the atrophied and compressed prostatic tissue being displaced and flattened around them. As has already been mentioned, these are thought by some authorities to be of an inflammatory origin rather than true neoplasms.

Thyroid adenomata are quite common, and may arise in connection with the lateral lobes, isthmus, or thyroglossal duct, in which case they may occur in the base of the tongue near the foramen cæcum and above the hyoid bone. These tumours are of one of two types:

(*a*) *Fœtal adenomata*, which are single tumours, usually of no great size, and consist of solid masses of spheroidal epithelium, resembling the structure met with in the developing thyroid. These are rare.

(*b*) *Adenomata of the type of the adult gland*, consisting of spaces lined with one layer of flattened spheroidal epithelium and filled with colloid, as in the normal gland, are by some authorities regarded as degenerated areas (p. 177). Such tumours are frequently multiple, and may attain considerable size, often consisting of one very large cystic space, into which hæmorrhage has occurred and caused destruction of the septa and epithelium. More rarely such tumours may undergo colloid degeneration, and then present an encapsuled mass of semi-translucent material, among which run strands of fibrous tissue, the remains of the septa—this is the so-called "colloid goitre"—or the fibrous septa may form a prominent part of the tumour (the fibrous goitre). All such tumours are definitely encapsuled, and may be enucleated, though usually, if many are present, removal of the affected lobe is necessary for their elimination. There is no doubt that in some cases of old-standing adenoma malignant changes supervene and the tumour becomes carcinomatous in type.

(*b*) MALIGNANT

(1) CARCINOMA

This usually occurs in persons over thirty-five years of age, but is very occasionally met with in young people. A carcinoma may commence in any type of epithelium, and differs from a papilloma or adenoma only in the fact that the epithelial cells can pass through the basement membrane, which normally separates them from the underlying tissues, and thus come to invade and replace these connective tissues among which they can be found lying; and that, moreover, following invasion of the lymphatics, and in the later stages, of the blood vessels, the neoplasm becomes widely disseminated throughout the body, giving rise to a series of

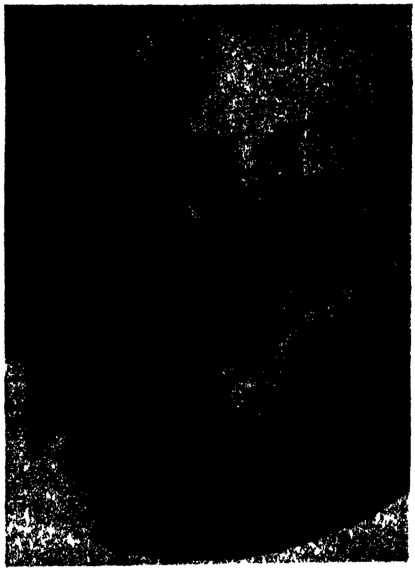


FIG. 84. Carcinoma in the skin spreading along lymphatics.

secondary deposits similar in type to the primary growth, and known as *metastases.*

It follows that the carcinoma will differ widely in appearance, according as it starts in squamous, columnar, or spheroidal epithelium, and will give rise to very varied clinical signs, according to the situation in which it commences; it will be necessary, therefore, to discuss these tumours under the varieties of epithelial cell they start in, and at the same time briefly to indicate the appearances met with in various parts of the body, though a detailed description of the clinical signs will be found under the surgery of the various organs.

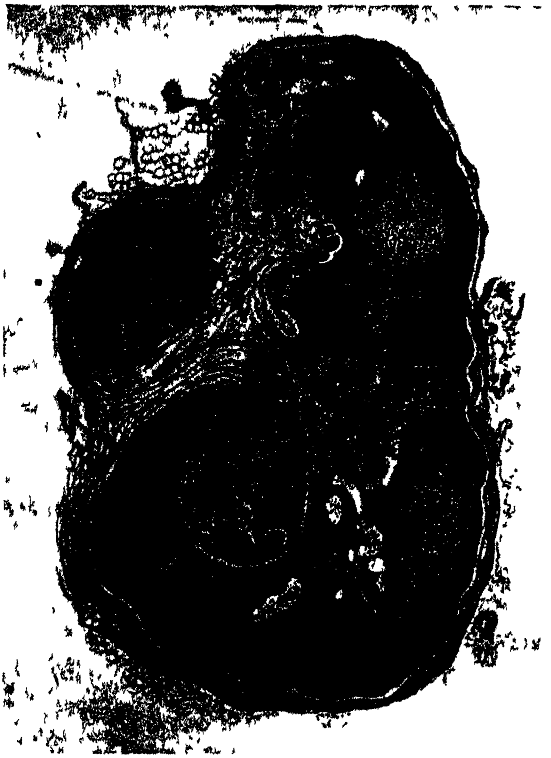


FIG. 85. Lymph node (× 18), showing carcinoma growing along the lymph vessels in the hilum, the node being otherwise uninvaded. Note the periadenitis.

The theories as to the cause of carcinoma have already been discussed briefly on p. 169, but before considering the various types of growth in detail, it will be well briefly to review the different means by which dissemination of carcinoma can occur, and to indicate what clinical features may be met with in each case.

Dissemination of carcinoma in the body may occur in four ways :—

1. By "*direct extension*" following the invasion of the surrounding tissues by the abnormally growing epithelium. This is indicated by a general increase in size of the neoplasm in all directions and its increasing fixity in the surrounding tissues. In those cases where the epithelium is destroyed by the tumour an ulcer results, in the floor of which the neoplasm is exposed, and as this is embryonic tissue ill adapted to resist infection, if such a complication occurs it is shown by extensive sloughing in the tumour and rapid increase of

the ulcer. As already discussed in Chapter VII., p. 152, the appearances of such a malignant ulcer are quite characteristic, with the raised everted edge and the hard mass of infiltrated and discoloured (dusky) tissue around.

2. *By way of the "lymphatic channels."* This method of spread has been very carefully worked out by Sampson Handley and other observers, who have shown it to be the common route of dissemination, and one by which extension may occur throughout large areas of the body; for, as already pointed out, lymphatic anastomosis is free, especially across the midline (Chapter V., p. 66). These observers have shown that this lymphatic dissemination follows the invasion of the lymphatics by the epithelial cells, and that these may then spread either :—

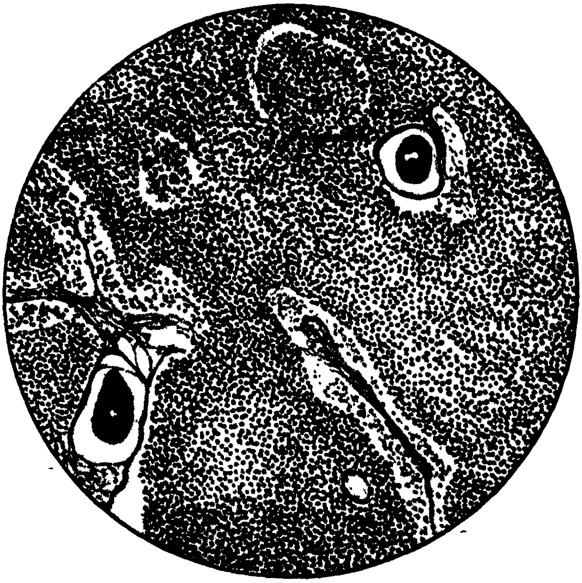


FIG. 86. Lymph node (× 65), showing carcinoma growing in lymph vessels (permeation).

(*a*) *By embolism*, a portion of or isolated cells of the neoplasm being broken off and carried along with the lymph stream until the lumen of the vessel so narrows that the cells become wedged. This narrowing normally occurs at the point where the vessel breaks up to enter the nearest lymph node, and it is, therefore, in the nodes of the nearest lymphatic group that metastases of carcinoma occur earliest and most often, and here they should be sought for.

In this relation, however, it must be borne in mind that the lymphatic vessel divides in the capsule around the node, and that it is, therefore, in this region that the embolus is arrested, and that it will not be for some considerable time that the gland will have become replaced by carcinomatous tissue, and so be detected as a hard mass. Glandular enlargement, therefore, occurs late, and indeed not till the carcinoma is probably disseminated beyond the affected nodes to the next group. But immediately following the arrest of the carcinoma embolus in the gland capsule, tissue reaction occurs, with subsequent fibrosis, and the gland becomes very early fixed in the surrounding connective tissue; this fixation can be detected clinically long before any glandular enlargement has occurred (Fig. 85).

(*b*) *By "permeation."* This term is applied to the method whereby the carcinoma cells grow along the lumen of the lymphatic vessel as a solid column in both directions from the point of invasion, but, of course, more rapidly in the direction of the lymph stream (Fig. 86). The whole lymphatic system around the growth thus becomes replaced by strands of malignant cells, which completely obliterate the vessels, and so cause a lymphatic œdema (Chapter XI., p. 308) peripheral to the tumour, a condition further aggravated by the fibrosis occurring around the lymphatics consequent on the protective inflammatory reaction set up in the tissues. This reaction may cause complete disappearance of the carcinomatous deposits, but these may, on the other hand, persist in some places, giving rise to a chain of isolated malignant nodules, between which fibrous strands can be demonstrated, these being the obliterated lymphatics.

Owing to the smaller size of the cells in spheroidal-celled carcinoma, this type is more generally and early disseminated *via* the lymphatics, while the larger squamous carcinoma cell is not so easily able to pass through the vessel lumen, but in all cases the metastases will be of the same type of epithelium as the primary growth.

3. *By the "blood stream."* Dissemination by this route undoubtedly occurs, usually from old-standing primary tumours, as the vessel walls are very resistant to invasion by malignant tissue, and thrombosis has frequently occurred in the vessel before it takes place. When it occurs, however, metastases may arise anywhere in the body, and are most frequently met with in the lungs or bones, particularly in the distal ends of the limbs.

FIG. 87. Malignant carcinomatous ulcer with raised everted edges.

4. *By direct implantation* from one part of an epithelial surface to another, as is not infrequently seen in the colon, where secondary seedling carcinomata occur lower down the bowel, having been broken off and carried along by peristalsis till deposited. Carcinoma cells can be transferred and implanted across one of the body cavities, *i.e.*, the peritoneum or pleura, in this way, and so give rise to metastases (*transcœlomic implantation*).

Before proceeding to deal with a carcinoma a surgeon always must conduct a very careful examination to ascertain the presence and extent of the metastases; and, secondly, he must be careful not to treat a secondary deposit as a primary tumour, an error of diagnosis which is most likely to occur in the case of secondary carcinoma in a bone, and which usually can be avoided by a careful search for a primary carcinoma, especially in the thyroid, prostate, or breast, before any bone tumour is finally diagnosed as a primary sarcoma; moreover, the bone reaction to secondary carcinoma, which is usually central in position, is very much slighter than in the case of an endosteal sarcoma, and, indeed, not infrequently is so completely absent that a pathological fracture of the affected bone may be the first sign of metastatic trouble (Chapters XIV. and XVIII.).

Degenerative changes are not infrequently met with either in the primary tumour or in secondary deposits of large size and result from necrosis of the masses of epithelial cells consequent on their poor blood supply; these changes are clinically manifested by softening of the mass, which on section may show either *fatty* degeneration, when its surface exudes a thinnish milky juice (cancer juice), or *colloid* degeneration, when the tumour is replaced by a translucent gelatinous mass; in either case hæmorrhage is liable to occur into the area, when a brown staining may be present.

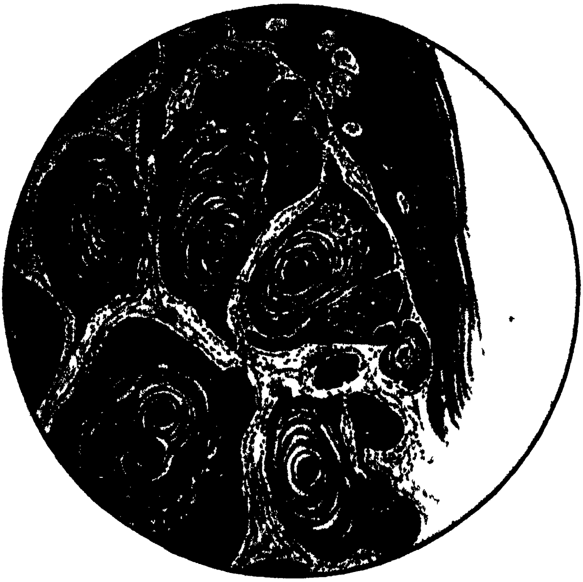


FIG. 88. Squamous-celled carcinoma (× 40). Note cell nests.

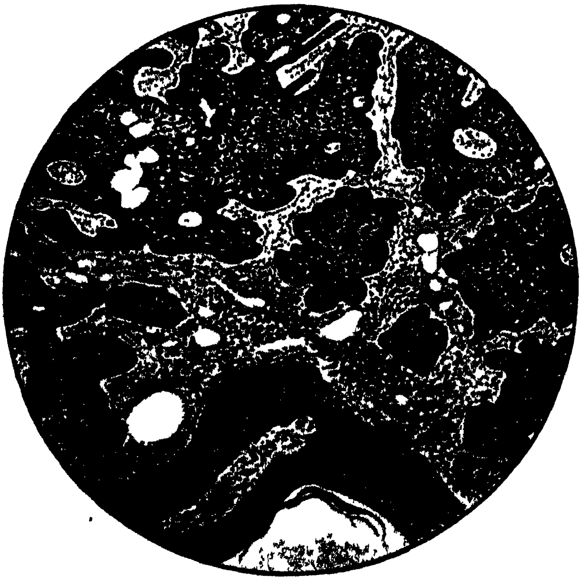


FIG. 89. Rodent ulcer (basal-celled carcinoma) (× 50).
Note no cell nests.

Microscopic Appearances. If the edges of the primary tumour be examined under the microscope, columns of epithelial cells can be seen pushing down into the surrounding tissues, which are densely infiltrated with lymphocytes and plasma cells around the advancing edges of the tumour; this in chronic cases becomes encapsuled in dense fibrous tissue, so being retarded in its progress. Such a mass feels hard to the touch, and on section presents a concave surface, which grates characteristically when rubbed with the knife

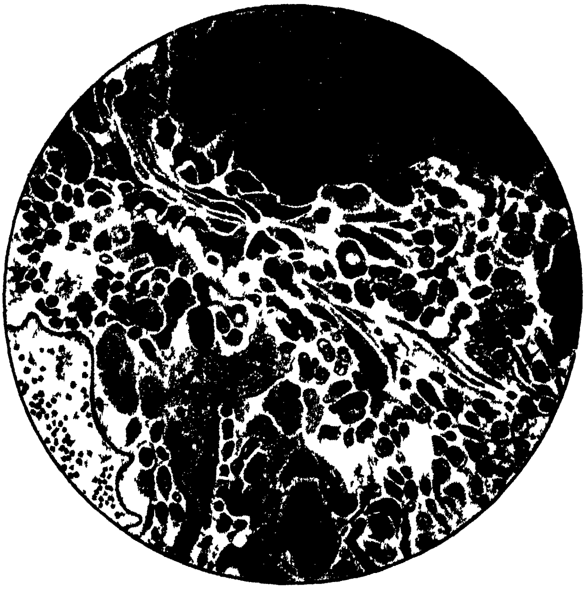


Fig. 90. Chorion epithelioma in the lung (× 175).

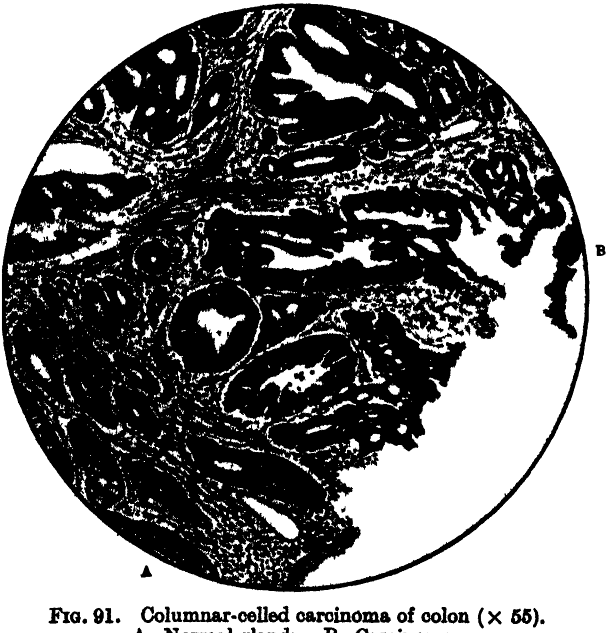


Fig. 91. Columnar-celled carcinoma of colon (× 55).
A. Normal glands; B. Carcinoma.

blade. It is known as a *scirrhous carcinoma*, in opposition to the softer, more rapidly growing type with but little fibrosis, the so-called *encephaloid carcinoma ;* in some cases where the fibrosis is very excessive, or the growth of low malignancy, the fibrous tissue practically may strangle the neoplasm and lead to extensive scarring and contracture, resulting in a condition known as *atrophic scirrhus*, which may persist for years without any detriment to the patient, who is usually aged.

It must be remembered that in a few cases spontaneous cure may occur as a result of this tissue reaction.

In men about three-quarters of the carcinomata occur in the mouth and alimentary canal, especially the tongue and stomach, whereas in women about the same proportion occur in the breast and uterus.

The treatment, as already indicated (p. 173), consists, where practicable, in excision in one mass of the tumour, together with its lymphatic vessels and the tissues in which they lie, and the nearest lymph nodes ; care must be taken to open up surrounding tissue as little as possible for fear of implanting carcinoma cells, and also to cut cleanly so as not to leave bruised tissues, which can ill resist the growth of such implantations, for which reason the diathermy knife is very valuable in excising malignant neoplasms. In inoperable cases X-rays should be tried, and deep ray therapy may give very satisfactory results and is always worth trying, but no opinion can be formed as to the probable success or otherwise of this treatment in any case. Radium should be used cautiously, for though it clears away sepsis and relieves pain, large doses undoubtedly stimulate the growth of metastases and of certain carcinomatous tumours ; Coley, in New York, using radon (radium emanation) seedlings, and Cade and others in London, with very small doses (0·2 to 2 mg.) of radium bromide applied interstitially over long periods, have succeeded in obtaining several apparently successful cures, and that without undue scarring and deformity. As a general rule, squamous-celled carcinoma yields readily to radium emanations, while spheroidal and columnar-celled tumours are more resistant ; glandular metastases are not usually suitable for radium therapy as the normal tissue cells are more sensitive to the gamma rays than the malignant cells, so that fibrosis results with islets of undestroyed malignant cells in the scar. Morphia should be given freely in the later stages of the disease.

(*a*) **Squamous-celled carcinomata** (epitheliomata) may occur in any squamous-celled epithelium, and are to be regarded as malignant papillomata, which not only grow outwards as warty excrescences, but also break through the basement membrane and penetrate the deeper structures ; they may be met with, as already stated, anywhere on the skin, in which case they may contain melanin pigment in their cells (Chapter IX., p. 245), the mucous membrane of the lips, tongue, mouth, pharynx, œsophagus, and anus, the penis, urethra and bladder, and the vulva, vagina, and outer surface of the cervix uteri in the female, or the vocal cords of the larynx. They may occur also in the central nervous system, which, it will be remembered, is developed from the embryonic epiderm, and as in this situation they are very liable to undergo degeneration and calcification, they have earned for themselves the name of " psammomata " (though some authorities regard this type of tumour as an endothelioma).

Clinically, carcinoma of the squamous epithelium may be of two types : (1) the " warty," where the main growth is on the surface, or (2) the " ulcerative," where the growth is of the penetrating type, and the surface epithelium rapidly becomes destroyed with the formation of a typical malignant ulcer (Chapter VII., p. 152). In both types sepsis is very apt to supervene in the exposed and poorly nourished carcinomatous tissue, with the production of a foul, sloughing mass, which rapidly increases in size, and shows signs of inflammation in the surrounding tissue and lymph nodes, which in consequence become enlarged and tender. Apart from sepsis, as already pointed out (p. 183), the nodes are not enlarged in the early stages, but merely matted and fixed in the surrounding tissues.

Microscopically, squamous carcinoma shows the arrangement of columns of stratified squamous cells, the central parts of which, corresponding to the superficial layers of the skin, undergo keratinisation, and form, when seen in transverse section, the typical "cell nests" so characteristic of squamous-celled carcinoma; while at the periphery of the columns some attempt at the "prickle cell" formation met with in the Malpighian layer of the dermis may be seen. There are two varieties of squamous-celled carcinoma which merit special notice, as they are typical in appearance:—

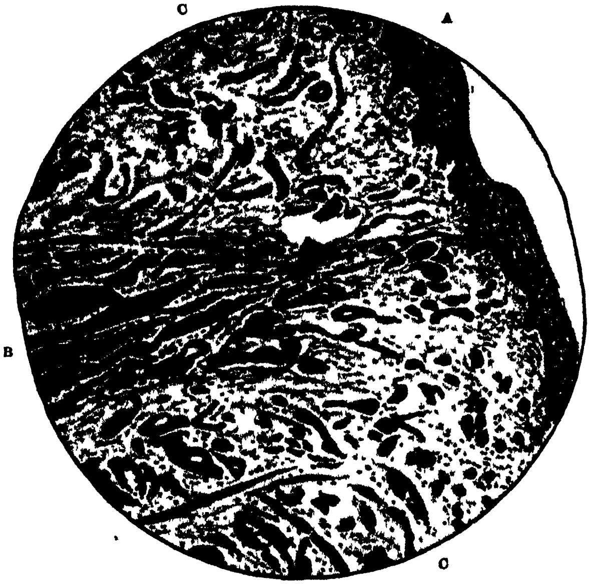


FIG. 92. Columnar-celled (duct) carcinoma of breast (× 65). A. Epithelium of nipple. B. Normal duct. C. Carcinoma.

(1) **Rodent ulcer,** which commences in the deeper layers of the dermis, and so shows no "cell nests" in the epithelial columns, and which also seldom gives rise to metastases in the lymph nodes (Chapter IX., p. 243).

(2) **Chorion-epithelioma,** which, starting in the ill-differentiated surface epiderm of the developing ovum, presents large masses of multinucleate undifferentiated protoplasm invading the uterine wall (Vol. II.).

Squamous carcinoma is very liable to supervene on chronic ulcers, or old lupus or burn scars, and may occur at the mouth of a chronic bone sinus; it also follows chronic irritation, as from a tooth stump rubbing on the side of the tongue, or from tar or dirt in such regions as the forearm or scrotum, and may follow on X-ray treatment if this has been carried out over a long period.

(*b*) **Columnar-celled carcinomata** may occur in the mucosa or tubular glands of the intestinal tract from the cardia of the stomach to the lower end of the rectum, in the gall-bladder and bile-ducts, in the renal pelvis and ureter, in the trachea, bronchi and air sinuses, the Fallopian tubes and uterine mucosa and cervical canal in the female, in the ducts of any gland, and rarely in branchial cysts or the apical glands of the tongue; the resulting neoplasm consists either of solid columns of cells, or of masses of columnar-cell-lined spaces (adeno-carcinoma) which can be seen invading the surrounding tissues after passing through the basement membrane. As in the case of the squamous variety, the growth may be either a warty mass or an ulcerating fissure, and is very liable to undergo colloid degeneration or become secondarily infected.

In growths occurring in the large intestine or pyloric end of the stomach, the consequent fibrosis in the surrounding tissue may lead to obstruction of the bowel lumen, a similar result not infrequently following in the case of carcinoma in the ducts of glands, where, however, less serious results occur.

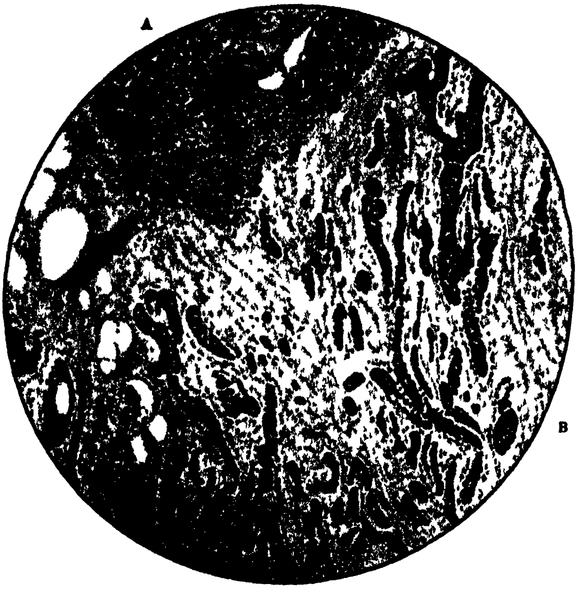


FIG. 93. Spheroidal-celled carcinoma of breast (× 75).
A. Chronic mastitis; normal acini and leucocytes.
B. Carcinoma.

(c) **Spheroidal-celled carcinoma** occurs in the secreting epithelium of any gland, and usually consists of solid columns of cuboidal cells, though occasionally acini may be present; but it is very unusual for the glandular secretion to be produced by the cells of the neoplasm, though this is undoubtedly so in some cases of adeno-carcinoma of the thyroid, where removal of the primary tumour has resulted in myxœdema, which has disappeared concurrently with the subsequent development of metastases.

The "scirrhous type" of this carcinoma is commonly met with in the breast, prostate, and from the racemose glands at the pyloric end of the stomach, while the "encephaloid form" occurs in the testis, kidney, and the breast of young lactating women, and is rapidly disseminated.

Owing to the smaller size of the spheroidal cells, this type of carcinoma is more rapidly disseminated than either the squamous or columnar-celled types, and is thus more "malignant," metastases being particularly common in the bones.

(2) HYPERNEPHROMA

This occurs as a localised tumour in the kidney or adrenal body, and more rarely in the testis, along the spermatic cord, or in the liver. Opinions differ as to the origin and nature of these tumours, but they are probably carcinomata starting in the cells of the renal tubules, in which degeneration produces in their structure changes which give rise to a striking resemblance to the zona fasciculata of the adrenal cortex, both in arrangement and in having the same characteristic orange-yellow colour, and this gave rise to the theory that hypernephromata arose in displaced islets of adrenal tissue. They are sometimes referred to as Grawitz tumours.

The tumour is usually apparently encapsuled, and displaces rather than invades the tissue in which it is situated; it may reach considerable size, and frequently contains cystic areas, which may consist of degenerated tissue or blood clot, and in rare cases calcification may be present. Definite lobulation is a marked feature, the fibrous capsule sending processes into the mass and dividing the lobules. Sooner or later, following invasion of the renal vein, metastases usually occur in the lungs (cannon-ball tumour—so-called from its round dense appearance on the X-ray film) or bones.

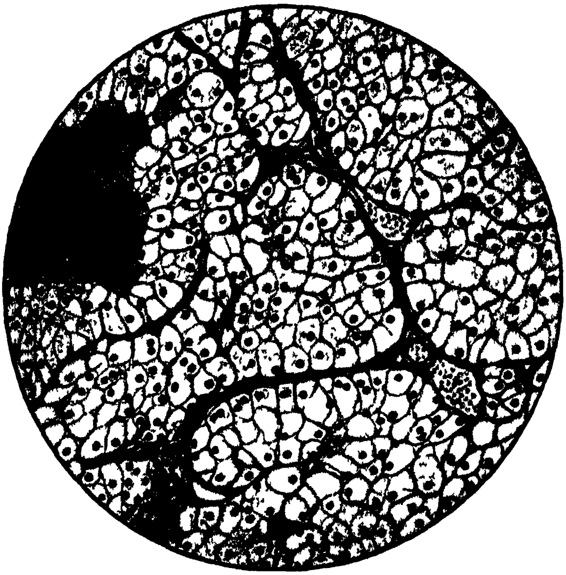


FIG. 94. Hypernephroma (× 200).

Microscopically, the tumour is seen to consist of columns of polyhedral cells, which can be shown to contain large amounts of fat, the columns being separated from each other by a small amount of fibrous tissue containing capillary vessels.

To the naked eye the mass presents a very characteristic appearance, the areas of typical orange-yellow tissue alternating with semi-fluid areas of brown degenerated tissue or blood clot. For these reasons the tumour has been called " the golden tumour."

The *metastases* may occur before the primary tumour has reached sufficient size to be detected clinically, and usually appear in the middle of the shafts of the long bones, where they give rise to a diffuse spindle-shaped swelling suggestive of syphilitic osteo-periostitis, or a sarcoma; they are usually diagnosed as one of these conditions until their removal or the discovery of a primary tumour reveals their true nature; in some few cases they may pulsate. Metastases in the lungs may be detected by X-ray pictures or by the onset of hæmoptysis.

The primary growth is usually in the upper renal pole, and therefore hard to discover, but a palpable kidney with associated attacks of hæmaturia is very suspicious of renal tumour.

(3) ADAMANTINOMA

This is a tumour usually seen in the pituitary region where it is thought to arise in the epithelium of Rathke's pouch and resembles in some ways part of a tooth germ. It also occurs in the jaw where it resembles fibrocystic disease of the jaw (so called), and has been described, see p. 206, in the tibia. It is doubtful whether it is malignant or not.

(4) MELANOMA

Melanotic cancers are the most malignant tumours known, and Dawson regards them as being all secondary to invasion by the melanin-forming cells of the epithelium, where pigmented moles of a simple nature become malignant and invade the underlying connective tissue and so disseminate both by the blood and lymph streams. The neoplasm grows from the pigmented areas of the body, such as the rete mucosum of the skin and the choroid of the eye. It may be round- or spindle-celled, and contains numberous dark brown or black granules of melanin, derived from the pigment cells. The origin of the melanin according to recent observers is always formed in the deeper cells of the rete Malpighium, from which it may escape through the basement membrane and be absorbed by connective tissue cells, which are in themselves incapable of producing melanin; it contains no iron, and may be deposited in the skin apart from the tumour or secreted in the urine. It is a remarkable fact that fair persons and animals appear more liable to this type of growth. The tumour frequently starts in a pigmented mole, which may begin to grow rapidly and ulcerate, or may remain so small as to escape notice, but in either case large masses of pigmented metastases quickly appear in the neighbouring lymph nodes and all about the body, the liver being a very common seat of secondary deposits.

The *alveolar type of pigmented growth*, frequently met with on the foot and known to be much less malignant, as it usually only forms lymphatic metastases, is probably a variety of carcinoma, as was originally suggested by Unna, and confirmed by the recent work of Dawson. It must be remembered that pigmented moles may enlarge at any time and are not necessarily malignant, but in view of the danger of malignant change occurring immediate removal always should be urged (Chapter IX., p. 245).

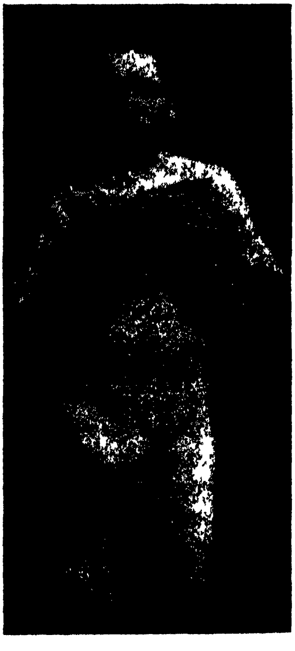


FIG. 95. Sarcoma of os pubis.

CONNECTIVE TISSUE TUMOURS

(a) SIMPLE

These consist of masses of connective tissue of the adult type, but as they are all derived from a common mesodermal origin, as might be expected, it is not uncommon to find two or more varieties of connective tissue in the same tumour. They are usually definitely encapsuled, have a good blood supply, and therefore do not undergo degenerative changes (an exception to this being seen in the case of fibromatous tumours, where the very nature of the tissue cuts off the blood supply, and so causes degeneration), but they tend to become more embryonic in character as they develop, and so pass into a sarcomatous condition and become malignant. Early removal, therefore, should be advocated in all cases.

I. LIPOMA

This type of tumour is perhaps the simplest form of new growth, as it closely resembles normal fat in appearance, being, however, rather paler in colour and usually definitely divided into lobules by connective tissue. The whole tumour, with its delicate membranous covering, is surrounded by a dense fibrous capsule, which is firmly fixed to the surrounding tissue, but only very loosely to the neoplasm, which, therefore, can be moved within its capsule. Such tumours never become malignant. They have more or less fibrous stroma and are sparingly supplied with blood by vessels which enter from the capsule usually by a definite pedicle at one spot.

Lipomata most frequently occur amongst the subcutaneous fatty tissue, and may be either single or multiple, but they can occur in other situations and are usually classified according to their position into :—

1. Subcutaneous lipomata.
2. Intermuscular or subfascial lipomata.
3. Parosteal or subperiosteal lipomata.
4. Subserous and subsynovial lipomata.
5. Submucous lipomata.

(1) **Subcutaneous lipomata** consist of a lobulated mass of fat, usually somewhat firmer in consistence than the surrounding fatty connective tissue, which may occur anywhere on the surface of the body.

Clinical Signs. The tumour forms a sharply defined lobulated swelling, with a definite rounded edge which, on pressure, slips from under the fingers and is attached to the skin by fibrous septa, so that dimpling can be demonstrated on stretching the skin over the tumour, but the mass is not fixed to the subjacent fascia or muscles. It is of a soft semi-fluctuant consistency, unless associated with much fibrous tissue, and may vary in size from a pea to a huge pedunculated mass weighing fifty or sixty pounds ; in the case of the larger tumours the whole mass may move down beneath the skin under the influence of gravity. These neoplasms may remain the same size for many years, and then suddenly increase rapidly in the course of a few weeks ; rarely they may undergo degeneration of a soapy or calcareous nature, and not infrequently, especially in young children, there is associated angiomatous tissue, the mass being then known as a "nævo-lipoma." When multiple the tumours are usually of no great size, and may be very numerous and painful.

The diagnosis is usually easy, the most characteristic features being the lobulation in a tumour not fixed to the deeper fascia, and the presence of the rounded margin which persists on hard pressure, but tends to slip or roll away from under the fingers. The conditions most likely to cause errors in diagnosis are a chronic abscess, which is, however, nearly always fixed to the deeper fascia and has no rounded edge when firm pressure is applied, and a sebaceous cyst, which is fixed to the skin at one point only, usually shows a black, blocked duct mouth, and is not lobulated.

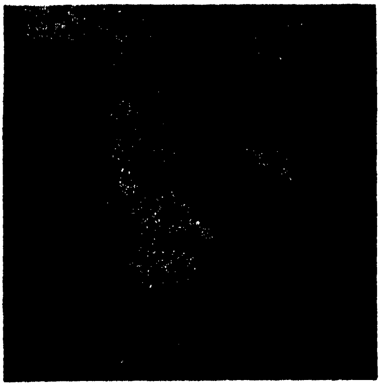


FIG. 96. Lipoma of chest wall.

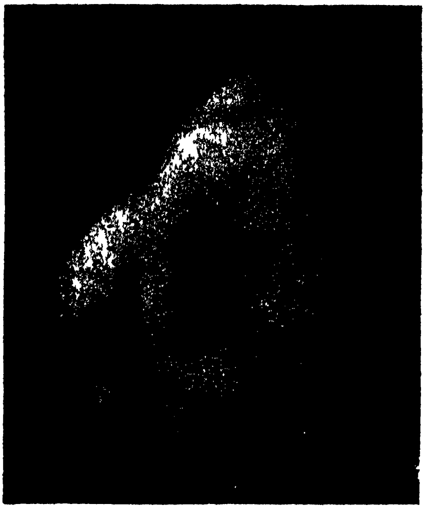


FIG. 97. Pedunculated lipoma of the back.

Treatment consists in shelling the lipoma out of its capsule, care being taken that no outlying lobule is broken off and left behind, as this results in recurrence of the mass.

(1*a*) **Diffuse subcutaneous lipomatosis** is not a true tumour formation, but is seen in various conditions of altered tissue metabolism, where large masses of fibro-fatty tissue get deposited in certain areas of the subcutaneous tissue. Such masses are not encapsuled and present no difference from the surrounding superficial fascia ; it is, therefore, not possible to excise them.

Such deposits occur (1) around the neck, both in front and behind, forming pendulous masses, usually in men with a history of chronic alcoholism ; (2) about the shoulders and limbs of women about the climacteric, this condition being often associated with severe pain and so known as "*adiposis dolorosa*" *or* "*Dercum's disease*"; (3) generally about the body in myxœdema and cretinism.

(2) **Subfascial and intermuscular lipomata** occur among the muscles, where they form soft masses, the lobulation in which it is usually impossible to detect on clinical examination. They may occur also in the tendon sheaths of the hand and foot, and are then frequently mistaken for "ganglion" (Chapter XIII., p. 396) ; otherwise they are usually diagnosed as chronic abscesses, the true diagnosis being discovered at operation.

The *treatment* consists in shelling out the tumour.

(3) **Parosteal lipomata** occur in connection with the periosteum of the bones, and if arising on the vertex of the skull are fairly easy of diagnosis, for, owing to their superficial position, lobulation can be detected. They may be mis-

taken, however, for malignant neoplasms or gummata. When occurring on the long bones they are usually mistaken for a soft sarcoma or chronic bone abscess. The frontal bone is a common site.

The *treatment* consists in excision. The tumour is usually firmly fixed to the periosteum at one spot only at which the vessels enter.

(4) **Subserous and Subsynovial Lipomata.** Subserous lipomata may occur beneath the visceral or parietal peritoneum, and are not infrequently seen in the inguinal region or along the linea alba, where they may be mistaken for a hernia, which, indeed, they not infrequently precede. In the case of the joints the condition is met with most frequently around the suprapatellar pouch of the knee, but the condition known as "lipoma arborescens" occurring in rheumatoid arthritis, cannot be regarded as a tumour formation (Chapter XIX., p. 609). The condition may be mistaken for a Baker's cyst.

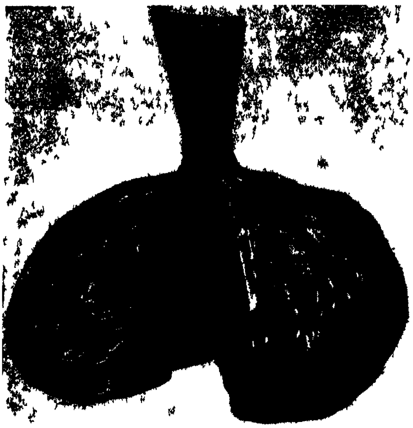


FIG. 98. Pedunculated fibroma of thigh.

The *treatment* consists in removal.

(5) **Submucous lipomata** may occur in the mouth, pharynx, larynx, or intestinal canal, and not infrequently cause obstruction to these canals which may be fatal. When occurring in the bowel they are a possible cause of chronic intussusception (Chapter XVI., Vol. II.). The condition is rare, and unlikely to be diagnosed apart from operation.

II. FIBROMA

This neoplasm is composed of white fibrous tissue, and may vary in consistency according to the type of tissue cell, from stony hardness to a semi-fluctuant consistency. Considering the wide distribution of fibrous tissue throughout the body, a pure fibroma is of rare occurrence, though fibrous tissue is, of course, present to a greater or lesser extent in the connective tissue stroma of all tumours and inflammatory masses. All fibromata show a marked tendency to undergo malignant change and become sarcomatous. Fibromata are usually classified as (1) hard and (2) soft.

(1) **Hard fibromata** consist of lobulated masses of glistening white fibrous tissue, which on section can be seen to be arranged in concentric whorls, the lobules being held together by a more or less dense connective tissue containing vessels. Such tumours may occur in any connective tissue, present a slightly lobulated surface, are hard and globular in shape, being definitely circumscribed but showing no definite capsule, as in the case of a lipoma, and, therefore, needing dissection for their removal. These tumours are met with in connection with the muco-periosteum of the jaws, forming one type of epulis (Chapter IV., Vol. II.), and the nasopharynx, and are fairly frequently seen arising in connection with the sheaths of peripheral nerves, when they form a "painful and hard subcutaneous nodule" if single, or, if multiple, give rise to a condition known as "neurofibromatosis."

Degenerative changes are frequently seen in hard fibromata, and cause mucoid or calcareous areas to appear in the tumour; or more rarely, probably owing to a mild infection, there occurs a process of autodigestion

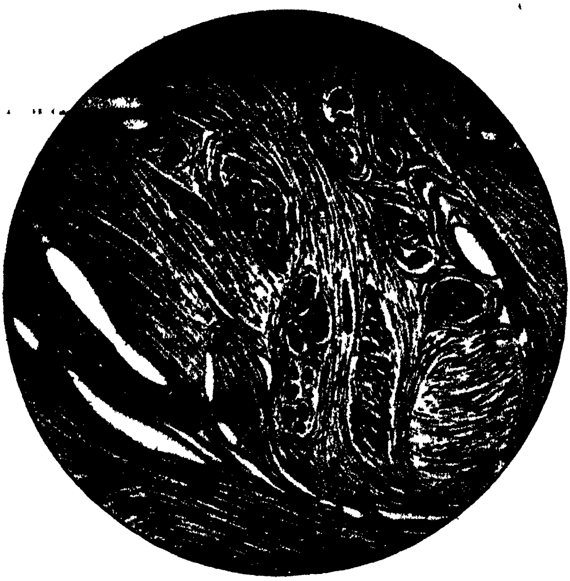


Fig. 99. Fibroma (× 65).

known as "necrobiosis," the whole mass appearing red and œdematous on section, a change more frequently seen in fibro-myomata than in pure fibroid tumours (Chapter XXII., Vol. II.).

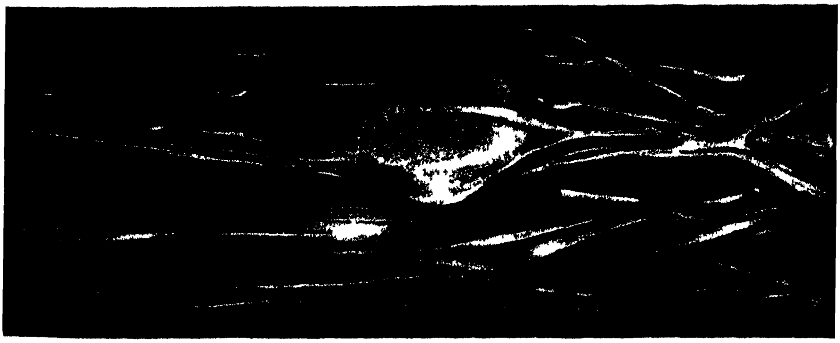


Fig. 100. Multiple neuro-fibromata of the brachial plexus.

(2) **Soft fibromata** differ from the hard variety only in their consistence and in the presence of a number of large veins amongst their lobules, so that should any injury occur to them they may bleed very freely. Owing to their soft structure they may be confused clinically with lipomata, but are of much rarer occurrence. Or again, they may be hard to diagnose from a sarcoma, and in some old-standing cases these neoplasms do undoubtedly undergo a transformation into a malignant tumour of a sarcomatous nature. Not infrequently these soft fibromata occur as either localised or diffuse

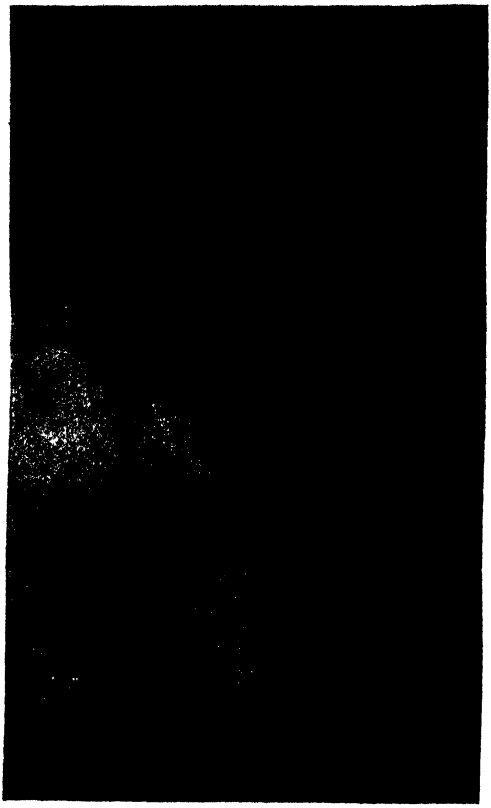


FIG. 101. Molluscum fibrosum with elephantiasis neuro-fibromatosum.

tumours on the nerve sheaths, and if of a large size may protrude from the cutaneous surface and form soft pedunculated tumours known as "**molluscum fibrosum,**" this being one form of "neuro-fibromatosis." Like the hard fibromata, these tumours may undergo degenerative changes, usually of a hyaline or mucoid type, and then present on section clear areas into which hæmorrhage may occur. The "Hottentot buttock" is an example of a diffuse soft fibroma.

The *diagnosis* of fibromata is often impossible unless a microscopic section of the tumour is examined, for, as already pointed out, the main bulk of other neoplasms may consist of hard or soft fibrous tissue which, by its contraction, may almost obliterate the other elements in the tumour; this is met with in fibro-adenomata of the breast and prostate, uterine fibro-myomata, and less commonly in other tumours. Moreover, in the case of "soft fibromata" difficulty may be experienced in diagnosing the condition from sarcomata, even under the microscope, and in these cases only a subsequent clinical history of recurrence may establish the true nature of the neoplasm; this is seen in the so-called "recurrent fibroma" of the older surgeons, which is now conceded to be a sarcoma of low malignancy.

The occurrence of fibromata in any tissue has been alluded to already, but there are certain situations where these tumours may be expected. These will be enumerated briefly :—

1. *In the skin and subcutaneous tissues,* where they may occur either as solitary tumours, or more often be multiple, when they are nearly always in association with the fibrous sheaths of the nerves; they give rise to multiple painful masses, varying in hardness and in size from a pea to a cricket ball in the cuticle and subcutaneous tissues, which constitute *von Recklinghausen's disease,* or *neuro-fibromatosis* (molluscum fibrosum). Occasionally a diffuse fibrous thickening of the nerves occurs, usually associated with hypertrophy and plication of the overlying skin, and this form of the disease is known as a "*plexiform neuroma.*"

Neuro-fibromatosis may affect a whole limb and is one of the causes of "gigantism." More rarely this condition may affect large areas of the superficial fascia and be accompanied by general fibrosis and lymphatic œdema of considerable areas, giving rise to large pendulous masses of vascular fibro-neuromatous tissue covered with hypertrophied skin, a condition called by Virchow "elephantiasis neuromatosa." In all these conditions sarcomatous change is likely to supervene in one or more of the masses, and is signalised by rapid growth and fixation of the affected tumours (see Chapter XII., p. 342).

Keloid scars are probably inflammatory in origin and not a true fibromatous neoplasm (Chapter II., p. 24).

2. Fibromata occur rarely *in the muscles and fascia* and around the periosteum of the bones, where they are usually confused with sarcoma. In this relation attention should be drawn to the tumours of this nature occasionally met with in the nasopharynx, and springing from the mucoperiosteum of the sphenoid or basi-occipital bones. More rarely still they may occur in the medullary cavity of the long bones.

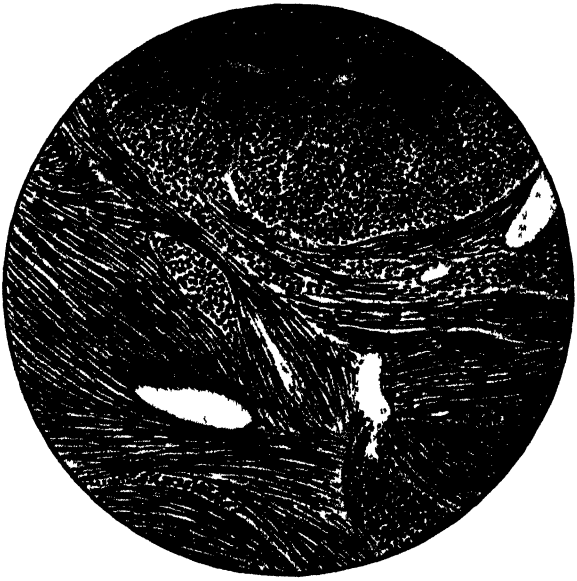


FIG 102. Fibromyoma of uterus (× 65).

3. Very occasionally fibromata occur in relation to the connective stroma of glandular organs such as the ovary, testis, or breast, though most often a careful examination of the whole tumour shows it to be a fibro-adenoma.

III. MYOMA

A muscle tumour may occur in any situation in which muscle is found, and inasmuch as there are normally two varieties of muscle, the smooth (involuntary) and the striped (voluntary), so, according to which type of muscle the neoplasm starts in, do we meet with **leiomyomata** or **rhabdomyomata**. Of these the *leiomyoma* (smooth muscle tumour) is by far the more common, and is usually met with in the uterine wall, where it is intimately associated with masses of fibrous tissue, and forms a circumscribed tumour known to the gynæcologist as a uterine "fibroid." A pure leiomyoma is of very rare occurrence, and, as in the uterus, so in the rare cases when such tumours are found in other situations where unstriped muscle occurs, such as the intestine, there is nearly always a close association with dense fibrous tissue.

Microscopically, it is often very difficult to distinguish between the smooth muscle cells, fibrous tissue, and spindle-celled sarcoma.

The diagnosis rests mainly in the fasciculated arrangement of the oblong and blunter-ended muscle cells, which are of the same type throughout the tumour, whereas the sarcoma cells tend to be more irregularly arranged and to present an embryonic appearance at the growing edges, the fibrous tissue shows less individual cells, and the strands tend to be curled. The appearance of the blood vessels also may be helpful in diagnosing between a benign and malignant tumour, for whereas in the former they have normal walls, in a sarcoma they are limited only by a single layer of endothelium, and often this is absent, the tissue cells abutting into the blood space.

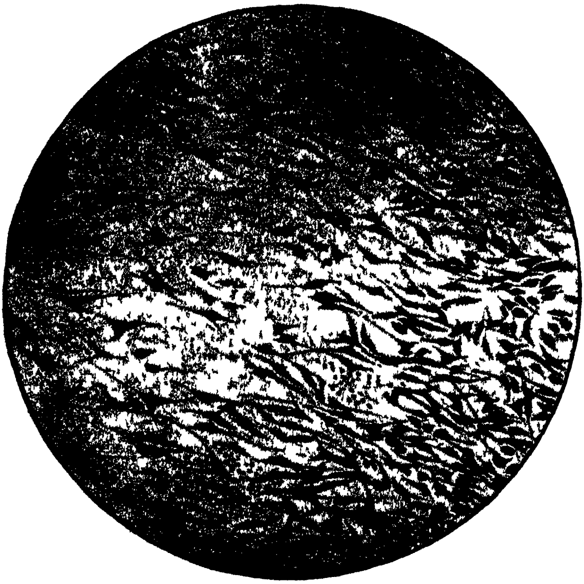


FIG. 103. Myxo-fibroma (× 200).

Rhabdomyomata are exceedingly rare, and do not occur *per se*, though striped muscle has been detected in certain sarcomatous and teratomatous tumours of the kidney and testis, and in a few cases of polypoid neoplasm at the base of the bladder in infants.

IV. MYXOMA

This is a rare tumour, and consists of a loose reticulum of branched connective tissue cells, among which lies a clear translucent jelly-like tissue of a ropy consistency, and closely resembling "Wharton's jelly" met with in the umbilical cord. Such neoplasms may occur in any connective tissue, and as they are very liable to become malignant should be removed freely as soon as diagnosed. It must be understood clearly that inflammatory masses of œdematous granulation tissue, such as are met with in the nose (nasal polyp), and the ear (aural polyp), in connection with disease of the underlying ethmoid and petrous bones respectively, are in no sense myxomatous neoplasms; and again a careful distinction must be drawn between a true myxoma and hyaline or mucoid degeneration occurring in simple (fibromata or myomata) or malignant (sarcomata) connective tissue tumours, or the colloid degeneration met with in certain types of malignant epithelial neoplasms (colloid carcinomata). In the former connection it should be borne in mind that gliomata in the central nervous system are often semi-translucent, and this probably has given rise to the inaccurate statement made by some surgeons that a "myxoma is the commonest simple tumour met with in the central nervous system," such tumours being in reality degenerated gliomata.

V. GLIOMA

This new growth is met with in connection with the neuroglia of the central nervous system and, therefore, may occur in the brain, spinal cord or retina, where it forms a poorly encapsuled mass of mono-nuclear cells with branching processes (glial cells) held together by loose connective tissue, closely resembling in appearance the surrounding brain tissue, from which it can be distinguished only with great difficulty. Such tumours are often the seat of hæmorrhages, or hyaline degeneration, either of which may give rise to cyst-formation or rapid increase in size of the neoplasm with sudden exacerbations of the symptoms caused thereby (Chapter I., Vol. II.). It should be noted that many so-called gliomata of the retina are in reality round-celled sarcomata (Chapter I., Vol. II.).

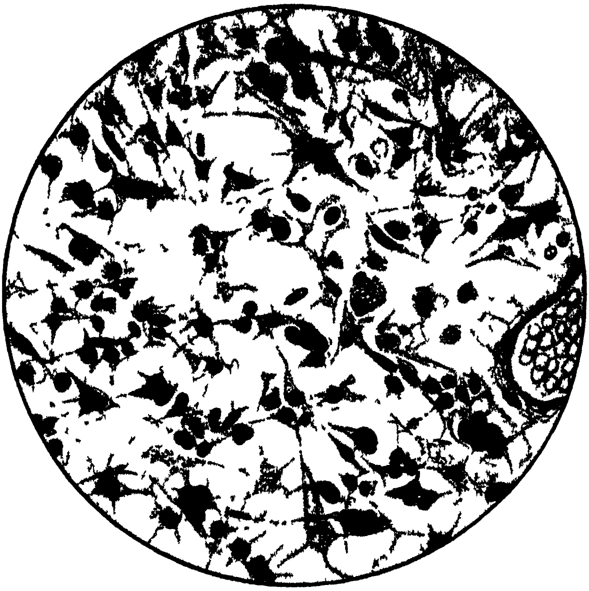


FIG. 104. Glioma (× 300).

As already stated, these tumours are seldom encapsuled, and therefore must be regarded as locally malignant, for, although they increase but slowly, they cannot be shelled out from the brain, which is usually enlarged, œdematous, and of a somewhat harder consistency than normal in the region of the tumour if this is situated deep to the grey matter of the cortex.

Gliomata never give rise to metastases, and thus can be distinguished from the sarcomata or carcinomata which also occur in these situations. It is a disputed point as to whether these gliomata are developed from the primary epiderm, which forms the central nervous system of the embryo, or from the connective tissue elements of mesodermal origin which subsequently invade and blend with the original epithelial tissue.

Cushing and Bailey have divided the gliomata into fourteen different varieties, according to varying malignancy and find very great differences in the prognosis of the different types. The three most important groups are :—

(1) Medullo-blastomata, apparently the most malignant.

(2) Spongio-blastomata, also very malignant.

(3) Astrocytomata, which have a more favourable prognosis. These constitute about 40 per cent. of all gliomata.

VI. NEUROMA

This is of such rare occurrence as hardly to merit mention—only some six or seven cases of true neuroma having been described. In all these cases there were many soft subcutaneous tumours which were diagnosed as lipomata, the masses not being painful, usually involving the sympathetic fibres, and in all cases containing ganglion cells as well as nerve fibrils.

" False " neuromata or fibromata occurring in the epi- and perineurium of the peripheral nerves are described under Fibroma on pp. 194 and 197.

VII. CHONDROMA

This is a cartilaginous tumour usually associated with cartilage or bone, but very rarely occurring in other tissues such as muscles, tendons, or connective tissue. The new growth nearly always consists of a series of lobules of semi-transparent avascular hyaline cartilage, with sparse connective tissue containing vessels between these, the whole being enclosed in a more or less definite fibrous capsule. Very rarely fibro-cartilage may be met with in such tumours, and these cases usually occur in the neck; there is a probability that such masses are really accessory auricles developing in association with the branchial clefts and not true neoplasms.

Microscopically the hyaline cartilage differs from that met with on the articular surfaces of joints in having the cells arranged irregularly and varied in shape.

Degenerative changes are common in these tumours, the most common being calcification and ossification, which may be so excessive that the mass appears on casual examination to be an osteoma or calcified fibro-myoma. Occasionally liquefactive necrosis occurs, with the formation of large cyst-like spaces. The chondromata not uncommonly undergo sarcomatous transformation, but, unless this is the case, they never invade the medullary canal of any bone from the exterior of which they may arise, however huge in size they may grow.

Clinically two types of chondroma are met with :—

(1) **The solitary type (ecchondroma)**, arising in an islet of cartilage on the surface of the osteum of a long bone, usually near one or other end, or in the costal cartilages, but having no apparent connection, either in development or growth, with the epiphyseal cartilage. These tumours form hard lobulated masses attached to the bone, and painless unless pressing on surrounding nerves; they may reach a huge size, as big as a football, and cause disorganisation of the limb by pressure, atrophy of surrounding structures, or

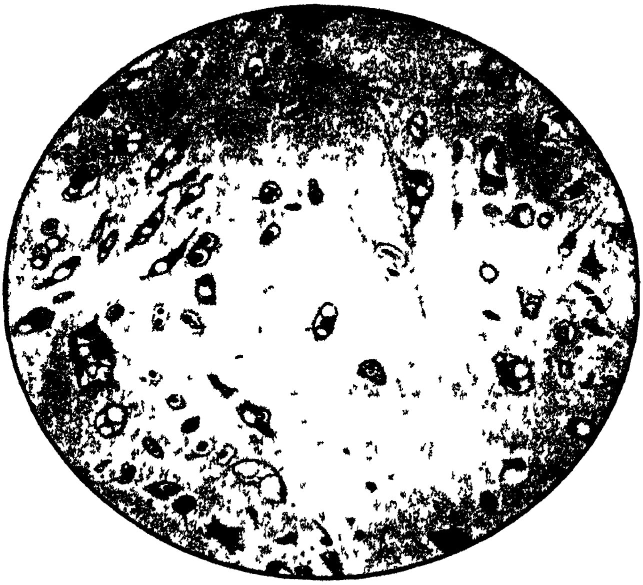


FIG. 105. Chondroma (× 200). Note irregular arrangement of cells.

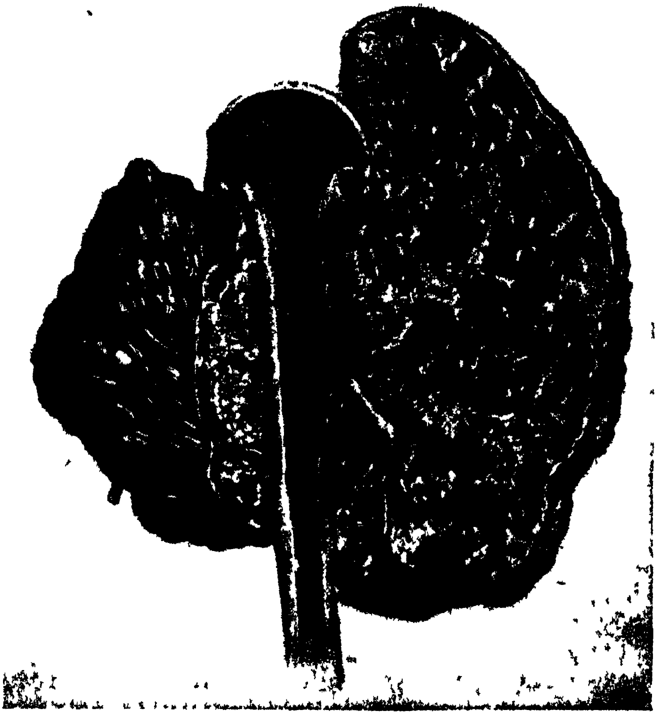


FIG. 106. Chondroma of humerus with central ossification. Note that the medullary cavity is intact and the shaft smooth beyond the tumour.

mechanical obstruction to movement. As already pointed out, these tumours frequently become sarcomatous, and then invade the medullary cavity and surrounding tissues. Unless calcified, these tumours show as clear areas in X-ray plates.

(2) **The "multiple" variety (enchondroma)**, arising in the short bones in the hands, and less commonly the feet, of young persons. The growth starts in the interior of the bone in the cancellous tissue and near the epiphyseal cartilage in the case of metacarpals and phalanges, and causes a fusiform diffuse expansion of the affected bone. Frequently one appears some time before the others are clinically obvious, and in all cases X-ray films should be employed, when the chondroma shows a clear area in the affected bone (unless, as occasionally happens, calcification or ossification have occurred in the neoplasm), the bone appearing thinned, expanded and sharply outlined around the central and frequently lobulated clear area of the chondroma.

Diagnosis in both cases is usually easy if X-rays can be used, but if not some doubt may arise in the case of these tumours as to whether the case is not one of *periosteal sarcoma*; or if, as is sometimes the case, the swelling has followed a definite trauma, *callus formation* around a fracture may be suspected. *Myelomata* and, in the case of the hand, *tuberculous* or *syphilitic dactylitis* also may give rise to confusion in diagnosis. In the case of the multiple tumours diagnosis may be confused with *multiple secondary sarcomata*, or, more rarely, carcinomata.

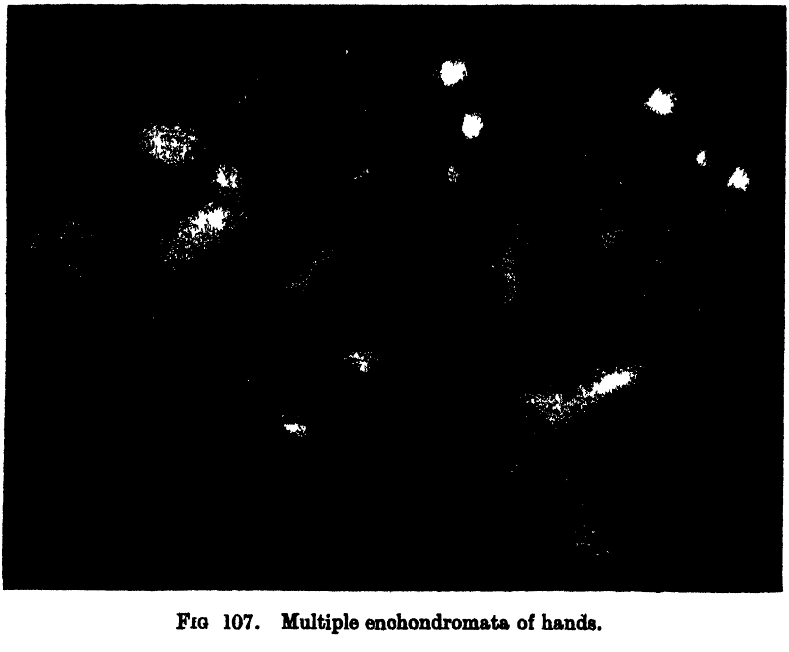


FIG 107. Multiple enchondromata of hands.

Treatment consists in attempting to shell out the neoplasm if not too large, but this is not an easy operation, owing to the lobulation of the mass, and "recurrence" due to the overlooking of a peripheral lobule in the bone is by no means uncommon. Where the tumour is large, or multiple tumours render the hand unsightly and useless, amputation will be necessary, and this always must be undertaken promptly if sarcomatous change has occurred.

Before leaving the subject of chondromata it may be well to mention briefly certain new formations of cartilage which occur in connection with the degenerative changes in joint structures associated with osteoarthritis (Chapter XIX., p. 607), which are in no sense neoplasms; these are called **ecchondroses**, and later become calcified and form osteophytes, but must not be mistaken for chondromata.

Such masses may arise (*a*) along the free edges of the articular cartilages, and if palpable subcutaneously are detectable as "lipping" or projections around the joint surface; (*b*) in "synovial fringes," where cartilage cells often may be present normally, and these may become detached, forming loose bodies in the joint. Swellings also occur in connection with the cartilages of the larynx and nose as diffuse hypertrophic thickenings. It must be borne in mind lastly, that cartilaginous masses are often met with in certain malignant teratomata, and occur also in sarcomatous tumours arising in connection with bones.

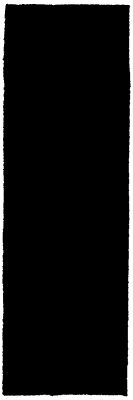


FIG. 108. X-ray of an enchondroma.

VIII. OSTEOMA

These tumours are new formations arising in connection with the bones and are of two varieties:—

1. Those associated with the cartilage bones of the trunk, extremities and basis cranii, having a porous consistency, like cancellous bone, and being known as *cancellous osteomata.*

2. Those associated with the membrane bones of the cranial vault and face, being solid, very hard, and known as *ivory osteomata.*

(1) **Cancellous osteomata** arise most frequently near the ends of the long bones, or in the vicinity of the epiphyseal cartilages of flat bones, and are derived from displaced islets of this cartilage; they are therefore or previous rickets has caused irregular growth of the epiphyseal cartilage. Such tumours are always capped with hyaline cartilage, usually appear just before or at puberty, and continue to grow till the normal time of fusion of the epiphysis from which they originate (*i.e.*, till the eighteenth to the twenty-fifth year), after which the cartilaginous cap disappears and growth in the tumour ceases.

FIG. 109. Cancellous osteoma Note the cartilage cap.

Such tumours may be pedunculated or sessile, are frequently capped with a bursal sac and often multiple, the most common situations being around the inner condyle of the femur and the upper ends of the tibia and humerus. Multiple chondromata occur in *Diaphysial osteoma*, a hereditary condition associated with dwarfism and irregular outgrowths from the epiphyseal cartilages.

Clinically these tumours present a hard nodular mass, usually larger at the periphery than at the point of attachment (mushroom-shaped), fixed to the bone and with the soft tissues moving freely over it. It must be remembered that should the superjacent bursa be enlarged fluctuation may be present over the hard mass, which, however, usually can be detected through or around the fluid swelling.

Treatment consists in exposing the tumour and chiselling it away, particular care being taken to remove completely the cartilaginous cap, or recurrence will occur.

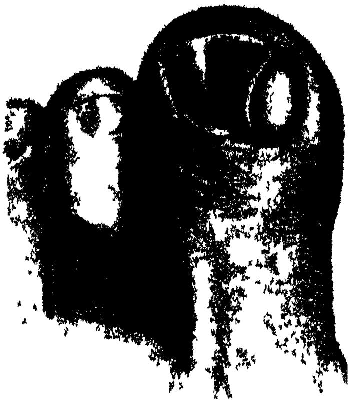


FIG. 110. Subungual exostosis. Note the typical appearance of the toe-nail.

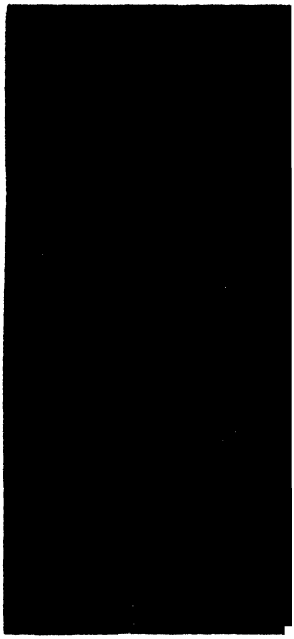


FIG. 111. X-ray appearances of Fig. 110.

Diagnosis. It may not be out of place to draw attention to the **subungual exostosis.** This is an osteomatous formation, possibly of inflammatory origin, which occurs under the nail, usually in association with the great toe. It is very painful, the nail becomes broken and deformed, and the tumour protrudes under its free edge. Ulceration next occurs, and the mass presents an appearance not unlike a cherry. The whole mass should be removed, together with the underlying bony tumour.

Other bony swellings resembling cancellous osteomata are sometimes met with :—

1. Around the joints in diseases such as osteoarthritis or Charcot's disease (Chapter XIX., pp. 607 and 614).

2. Around fractures, where excessive new bone formation may occur following suppuration, or in cases of tabes dorsalis (Chapter XIV., p. 419).

3. Following chronic infection of the accessory air sinuses, when the large masses of inflammatory cancellous bone formed subcutaneously much distort the face and give rise to a condition known as *leontiasis ossium,* Fig. 256, p. 534 (Chapters IV. and VII., Vol. II.).

4. In ossifying chondromata and sarcomata arising in connection with bones.

5. Following injury to the periosteum, which allows bone cells to escape

into the surrounding muscles and fasciæ; there they develop into masses of bone which cause atrophy of the affected muscle, a condition known as *myositis ossificans* (Chapter XIII., p. 388).

(2) **Ivory osteomata** arise, as previously stated, in connection with the membrane bones of the vault of the skull, and may occur (*a*) on the outer table, when they form a hard, rounded sessile mass in connection with the skull, or (*b*) on the inner table, when they project into the cranial cavity, and are not diagnosed unless they press on some motor or sensory centre, in which case they give rise to fits of either the Jacksonian or true epileptiform type, and are then to be located by the type and distribution of the symptoms produced. They may occur also in the orbit, displacing the eyeball, or block up the cavity of one of the air sinuses. If occurring in the external auditory meatus they may cause deafness and vertigo.

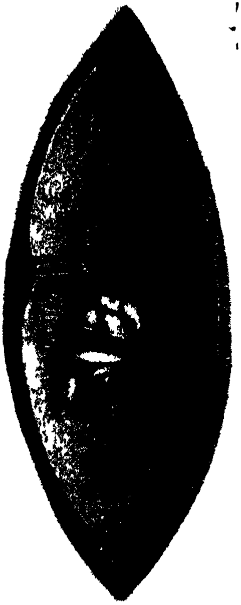


FIG. 112. Ivory osteoma on the inner aspect of the skull.

FIG. 113. X-ray of an ivory osteoma in the frontal sinus.

The *treatment* consists in removal when causing symptoms; this, owing to the great density of the tumour, is no easy task, and may result in fracture of the surrounding bone. It is usually easier to cut away part of the bone with the tumour attached, if this is feasible.

Rarely necrosis of the osteoma, with spontaneous separation, may occur.

IX. ODONTOMA

These tumours arise in connection with the tooth germs, and usually occur in the lower jaw, where they cause a diffuse expansion of the mandible with consequent disability and disfigurement. Inasmuch as both epiderm (enamel organ) and mesoderm (cement substance and dentine) enter into the formation of every tooth, such tumours may be epithelial, mesodermal, or contain a mixture of tissues, which last is frequently the case. It is customary to follow

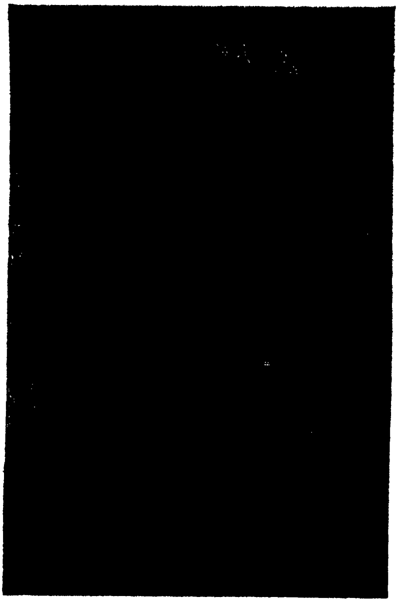


FIG. 114 Fibrocystic disease of the mandible.

the classification of these tumours laid down by Bland-Sutton, which, if unsatisfactory from an ætiological standpoint, is at least the most practical enunciated. Only two of the varieties so described are common in man, and they will be discussed first, the rarer varieties next, and those met with in the lower animals merely enumerated.

(1) **Epithelial odontoma (fibrocystic disease of jaw)** is an epithelial tumour arising in connection with the enamel organ, which is a down-growth from the epiderm, and is of the nature of an adenoma; so it should, strictly speaking, not be included among connective tissue tumours, but inasmuch as it is one of the commonest forms of neoplasm met with in connection with the developing teeth, is most conveniently considered with them. This tumour is probably very similar in origin to the adamantinoma found in the pituitary region, and occasionally in bones (see Chapter I., Vol. II.). The new growth consists of a mass of epithelial-lined spaces, filled with mucoid fluid, with dense fibrous connective tissue between and around them, the whole being situated in the substance of the jaw which becomes expanded around it. The tumours usually occur in the lower jaw of young adults (from twenty to thirty years of age), and often reach a very large size.

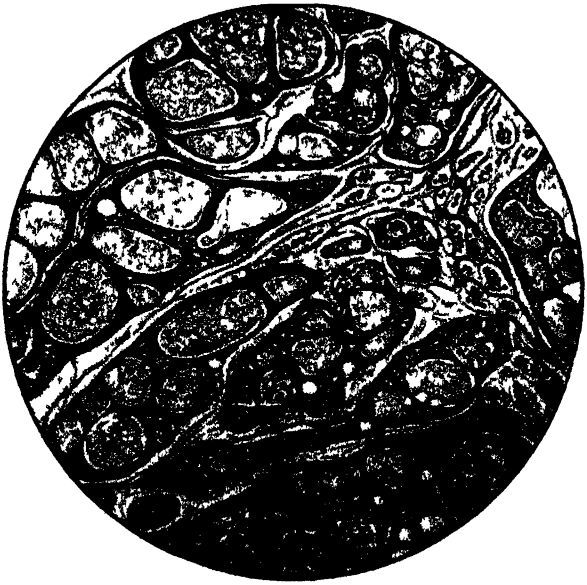


FIG. 115. Cylindroma of the jaw (× 65). "Fibrocystic disease."

Treatment in the early stages consists in enucleation, but when the mass is large excision of the affected ramus of the jaw is indicated.

(2) **Follicular Odontoma (Dentigerous Cyst).** This is a mesodermal tumour, and arises in connection with the capsule of an unerupted and often misplaced tooth, which is often lying horizontally in the wall of the cyst, where it can be easily detected on X-ray examination (see Chapter IV., Vol. II.).

This condition needs to be diagnosed from a *dental cyst* which occurs in connection with the carious fang of an erupted tooth, and is really a very chronic abscess cavity, with perhaps some inflammatory overgrowth of the remains of the enamel organ in its wall. X-ray films will reveal the carious stump in the wall of the cyst (see Chapter IV., Vol. II.).

Treatment consists in excision of as much as possible of the cyst wall and removal of the tooth.

Both these conditions are again dealt with in Chapter IV., Vol. II.

(3) **Composite Odontoma.** These are not often met with, and consist of a hard lobulated mass of all the structures, enamel, cement, and dentine composing a tooth, to which, however, such a tumour bears no resemblance. They can be removed easily, as they have no definite connection with the surrounding bone, but lie loosely in a cavity in this structure.

(4) **Radicular odontoma** occurs as an irregular mass in connection with the roots of an apparently normal erupted tooth, and, as the crown is not involved, contains no enamel.

(5) **Cementoma** results from ossification of the fibrous capsule around the developing tooth germ.

(6) **Fibrous odontoma,** which probably never occurs in man, though common in the lower animals as a fibrous tumour expanding the jaw around an unerupted tooth. It may be regarded as due to fibrosis round a dentigerous cyst.

(7) **Compound follicular odontoma,** which is a follicular odontoma involving more than one tooth germ.

X. ANGIOMA

This is a vascular tumour arising in connection with the blood vessels (hæmangioma) or lymphatics (lymphangioma); such neoplasms are usually congenital, and often associated with a certain amount of fibro-lipomatous tissue, when they are called nævo-lipomata. (The term *Nævus,* which is often used to indicate a hæmangioma, really means a congenital mole or natural mark, such as a pigmented papilloma or hairy mole.) It is possible that they are really of the nature of endotheliomata with no elastic tissue in their vessel walls.

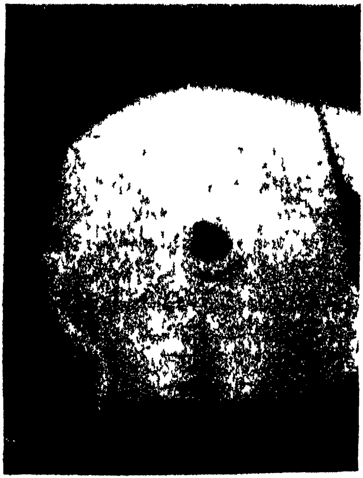


FIG. 116. Capillary nævus above a cavernous one.

(*a*) **Hæmangiomata** vary much in character, according to the type of blood vessel from which they arise; if congenital they usually occur in the skin or subcutaneous tissue, and give rise to a discoloured tumour which may often increase in size, while, if developing later in life, they frequently occur in the solid viscera, such as the liver; but it must be understood that they may arise in connection with the vessels of any tissue, as diverse as those of the penis or tendon sheaths of the palm of the hand. These tumours are classified according to their structure into capillary, cavernous (venous), and plexiform (arterial) angiomata. Many of them are mixed in type.

(1) **Capillary hæmangiomata** constitute the most common variety, and are usually congenital, occurring most frequently about the head and face, and more commonly in female infants. They consist of a mass of dilated cutaneous capillaries with a small amount of connective tissue; they are not usually raised above the skin surface unless they are very large, when a papillomatous condition of the cuticle is often found together with the presence of hair (hairy pigmented mole), or there is an associated cavernous nævus in the subcutaneous tissue. Such tumours are popularly known as "birth marks"; if small as "strawberry" or "mothers' marks," and if large as "port wine stains," and then may cover very large areas, even up to half the body. A common type is the "spider" nævus met with on the face and trunk in small babies, and consisting of a small central whorl of capillaries with fine linear vessels radiating from this; another variety of these telangiectases is met with in adult life in the form of small raised red spots, usually occurring on the abdominal wall, which consist of thin-walled dilated capillaries, and are frequently, but not always, associated with mammary or intestinal carcinoma; they were said always to indicate the presence of these diseases according to Campbell de Morgan, with whose name this nævoid condition is associated. A nævoid condition not infrequently develops in connection with extensive scars.

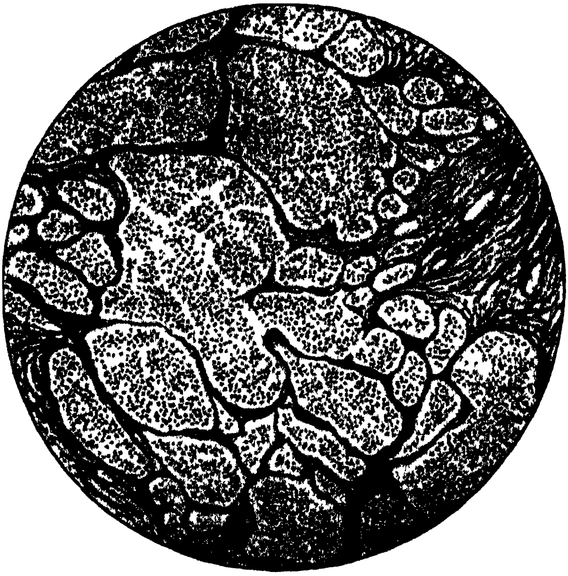


FIG. 117. Hæmangioma (×45).

The *diagnosis* is usually easy, though, occasionally, a pigmented hairy mole may cause difficulty in determining if nævoid tissue is present.

Treatment. In the case of small telangiectases treatment presents no difficulties and consists in destruction of the capillaries without destroying the skin, either by the application of CO_2 snow in a presser for thirty seconds, the application of radium, or by electrolysis by means of needles. In the case of larger nævi, and if a cavernous tumour is associated, excision should be advocated.

The problem of the treatment of the large "port wine stains" is a matter of some trouble, and usually such lesions are best left alone, as methods aiming at the destruction of the vessels are not satisfactory in their results, and are at best succeeded by extensive scarring.

(2) **Cavernous angiomata** may be congenital, when they usually occur in the subcutaneous tissues, or acquired, when they occur in solid viscera, such as the liver. On section they consist of a series of endothelial-lined blood spaces, and closely resemble erectile tissue, the arteries opening directly into the thin-walled spaces. It must be remembered that these tumours, like the capillary variety, may occur in or deep to mucous membranes, when they are liable to ulcerate, a complication associated with severe hæmorrhage, which, if recurrent, and following on septic infection of the area, may prove fatal.

Clinically such tumours present a soft spongy mass in the tissues, the size of which can be greatly reduced on pressure, and which gradually refills with blood when released. The skin over it may be discoloured. This feature of "compressibility" is characteristic.

The *diagnosis* is usually easy in the case of subcutaneous tumours, though it may be difficult to determine how much nævoid tissue is present in a nævolipoma. In such organs as the liver angiomata are usually only discovered post-mortem, as they rarely reach sufficient size in life to cause clinically detectable hepatic enlargement.

Rarely angiomata may occur in the tendon sheaths or synovial membrane of joints, and are then liable to be mistaken for tuberculous inflammation.

The *treatment* consists in complete excision if feasible, but in the case of very large tumours this may be inadvisable, as considerable hæmorrhage from the supplying vessels will be met with during the operation; in this case electrolysis by the electric needle or, better, with the diathermy cautery often will give satisfactory results. Occasionally spontaneous cure may occur from thrombosis following injury or infection. Good results may be obtained occasionally in this variety of angioma by injecting them with quinine and urethrane or sodium morrhuate as in the case of varicose veins (see p. 288).

FIG. 118. Cavernous hæmangioma of ear and cheek.

(3) **Plexiform angiomata** arise in connection with the arteries, usually in the scalp or neck, and may take the form of a mass of interlacing and anastomosing arterioles (*cirsoid aneurysm*), or of a series of largish lacuniform spaces containing arterial blood (*aneurysm by anastomosis*) (see p. 279). The tumours tend to increase in size, and should injury or infection occur, severe hæmorrhage may result.

Clinically either variety presents a raised, pulsating, irregular tumour, resembling a bag of worms, the skin over which is atrophic and devoid of hair. If arising in the orbit one form of "pulsating exophthalmos" is produced (other causes are aneurysm of the ophthalmic or internal carotid arteries, arterio-venous aneurysm and sarcoma). Rarely the condition may be met with in the cancellous tissue of long bones, when it gives rise to considerable pain, or on the surface of the brain.

Diagnosis is usually easy, the presence of pulsation serving to distinguish cirsoid aneurysm of the scalp from " pachydermatocele " due to diffuse neurofibromatosis. Transmitted pulsation in the veins near an arterio-venous aneurysm may cause difficulty in diagnosis.

Treatment. Excision may be attempted if the tumour is not too large, but haemorrhage is difficult to control, and better results are frequently obtained by simple ligature of the vessels feeding the tumour.

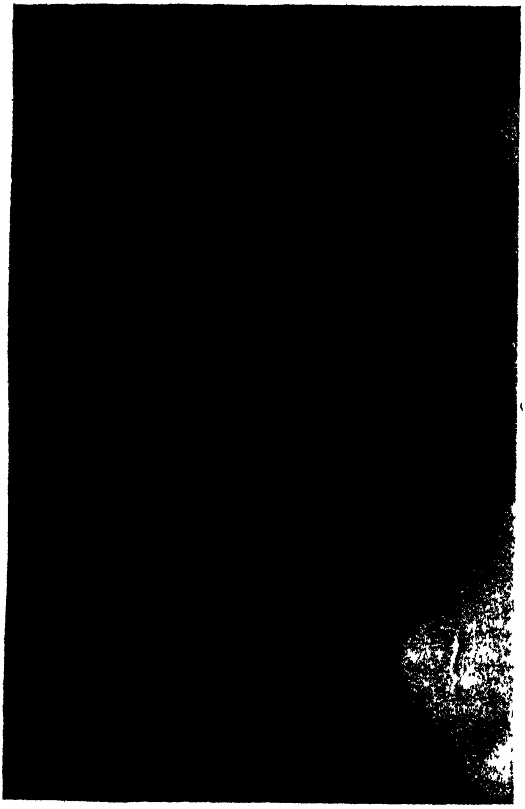


FIG. 119. Pachydermatocele.

(*b*) **Lymphangiomata** are of the same types as hæmangiomata.

(1) **Capillary lymphangiomata** are very rare, but occasionally occur on the conjunctiva as minute pearl-like globules, and in the posterior triangles of the neck, where they form ill-defined soft swellings, which vary in size from time to time and may cause pain from pressure on the brachial plexus when engorged.

(2) **Cavernous lymphangiomata (cystic hygromata)** are congenital tumours which frequently increase rapidly in size after birth. They usually occur in the neck or axilla, but may be met with along the spermatic cord (diffuse hydrocele of cord) (see Chapter XXI., Vol. II.).

Clinically these neoplasms consist of large cystic tumours, usually lobulated and covered with normal skin, which is, however, often thin and shows the bluish-white colour of the lymph in the subjacent cystic spaces. The mass is usually adherent to the skin and deeper structures, among which it may ramify extensively; if the cysts are large fluctuation will be present. Such tumours are liable to recurrent attacks of inflammation, which is probably due to lymph-borne infections, during which the skin is red and the mass enlarges and becomes painful, tense and tender, considerable febrile disturbance being present. This inflammation subsides spontaneously.

Diagnosis usually presents no difficulty, but should the patient be seen first during an attack of inflammation, care must be taken to differentiate it from acute abscess, as incision is to be avoided.

The *treatment* consists in excision—by no means an easy operation to perform completely, owing to the ill definition and extensive deep ramification of these tumours.

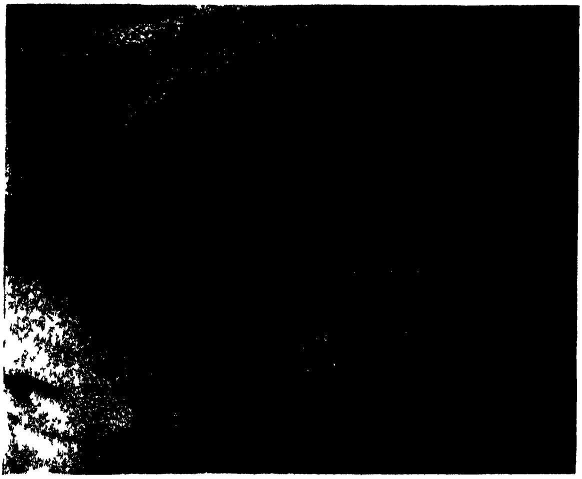


FIG. 120. Large cavernous lymphangioma in the neck of an infant.

(3) **Plexiform lymphangiomata** occur in the tongue and lips and give rise to one variety of macroglossia and macrocheilia. Care must be taken to diagnose the condition from that following lymphatic obstruction due to chronic inflammation such as occurs in tertiary syphilis, and that form of macroglossia due to neuro-fibromatosis—the diagnosis usually only being established on microscopical examination of the affected tissue.

Treatment is palliative, and consists in removing a wedge-shaped portion of the affected organ, so as to permit of the mouth being closed.

Lymphomata are described, but the vast majority of these are either inflammatory hyperplasia of lymphatic tissue, as occurs in lymphadenoma and lymphatic leukæmia, or else lympho-sarcomata.

(*b*) MALIGNANT

Malignant connective tissue tumours fall into two classes:—

(A) *Locally malignant* tumours, which have no definite capsule, or, at best, an incomplete "false capsule," but which do not give rise ordinarily to metastases. These include two types of tumour, (1) the endothelioma and perithelioma arising in connection with the walls of blood vessels and occurring usually in the salivary glands, and (2) the myeloma (osteoclastoma), which grows in the red marrow of bones, the predominant cell being the multinucleate osteoclast.

(1) ENDOTHELIOMA

These arise in connection with the lining membranes of the blood vessels, and usually consist of columns of endothelial cells, among which lie spaces representing vessel lumina, the whole being enclosed in a connective tissue stroma, which may be soft and vascular or densely fibrous. A special variety, arising in connection with the tunica adventitia, and showing solid columns of cuboidal cells lying around vascular lumina in a fibrous stroma, is known as a **perithelioma.** Endotheliomata may occur in any tissue, and are seen in connection with the carotid body in the neck, where they were originally described by Hutchinson as his "potato tumour" (see Chapter X., Vol. II.). Similar small tumours arising in connection with the meninges give rise to one form of "psammoma," the cut endothelial columns resembling "cell nests" in superficial examination (see Chapter I., Vol. II.).

Certain tumours in the salivary glands are endotheliomata.

Clinically such neoplasms present a localised swelling, which increases slowly in size, and gradually loses its definite edges as it infiltrates and becomes fixed to the surrounding tissues. Later more rapid increase in size occurs, and the tumour may soften and become cystic in places due to myxomatous or hyaline degeneration in the connective tissue stroma, nodules of cartilaginous hardness often being palpable in the mass. Such tumours frequently "recur" locally after removal, and very rarely may give rise to metastases, this usually being the sequel of a sarcomatous change in the connective tissue stroma.

Treatment consists of early free excision, as the sooner the neoplasm is removed the greater the chance of success.

Diagnosis may be difficult, as such endothelial tumours in the early stages are likely to be confused with chronically inflamed lymph nodes.

(2) OSTEOCLASTOMA (MYELOMA)

These tumours, which used to be classed with the rapidly growing sarcomata in which multinucleate masses of undifferentiated protoplasm occur, are now known to occur in connection with abnormal activity of the osteoclasts at the ends of long bones, and are regarded as a separate class of tumour of low local malignancy, though a few undoubted cases of metastases in the lungs in association with myelomata are on record. Such neoplasms present a characteristic maroon colour on section, are very soft, and often contain many cystic spaces filled with blood clot in the recent state ; if old-standing, the spaces contain serum and show yellow-staining, due to hæmatoidin, among the fibrinous clot in the cyst wall, these spaces resulting from hæmorrhages into the vascular tumour. Under the microscope large numbers of multinuclear osteoclasts are seen, which show many branching processes and are embedded in a dense mass of mononuclear spindle cells, among which lie numerous blood spaces. A very accurate opinion can be formed as to the malignancy of these neoplasms by noting if the stroma is fibrotic and contains much hæmorrhage (when they seldom recur), or consists of actively proliferating cells (when they are really sarcomata). There is no definite fibrous capsule, the cells lying against the tissues of the surrounding marrow and bone. Owing to their vascularity myelomata may pulsate, or a murmur may be detected on listening over them with a stethoscope.

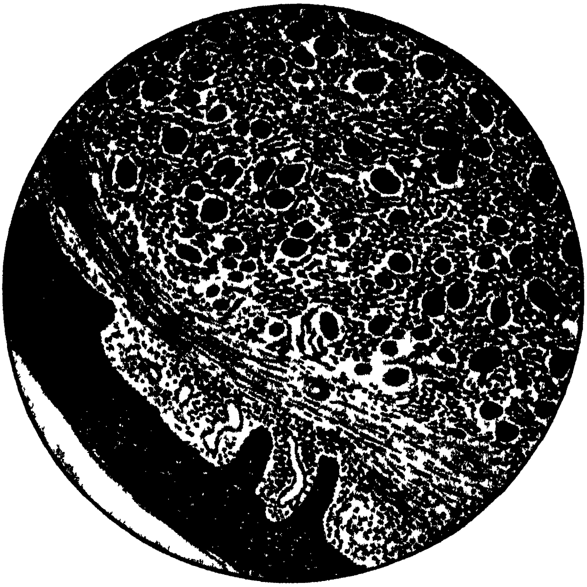


FIG. 121. Myeloma of jaw (× 65).

Many American authorities, notably Ewing, regard the various types of myeloma as separate varieties derived in the first place from a common condition, osteitis fibrosa cystica, in which the cancellous bone trabeculæ are absorbed and replaced by fibrous septa which persist among the osteoclasts and the blood vessels, which often enlarge to angiomata.

The types of giant-celled tumours met with in the bones may be roughly classified:

(1) **Typical myeloma**; many bloodfilled cystic spaces, among a network of connective tissue with giant cells; the tumour is maroon-coloured from the blood, and surrounded by a thin shell of new bone.

(2) **Xantho-myeloma**; solid masses of fibrous tissue, with perhaps a few cysts, yellowish colour and little or no new bone around, so that pathological fracture occurs early. (This type commonly occurs in connection with tendon sheaths, see p. 195 and Chapter XIII., p. 400.)

(3) **Myxo-myeloma**; much loculated, cystic cavities filled with colloid mucilaginous material which may be arising in thyroid rests in the bone.

(4) **Angio-myeloma**; large spaces filled with blood and lined with endothelium, separated by fibrous tissue containing giant cells.

(5) **Doubtful tumours**; often apparently arising in aberrant islets of cartilage and occurring near the ends of long bones only, are rarely seen, but tend to form metastases. Hyaline cartilage may occur microscopically in such neoplasms.

(6) **Giant-celled sarcoma**; masses of multinucleate undifferentiated protoplasm occur in rapidly growing round-celled sarcomata, which are very malignant and form early metastases (p. 218).

Clinically there is a gradually increasing diffuse rounded enlargement of the end of the affected bone, often the upper end of the tibia, which becomes much thinned over the tumour and may fracture on pressure, giving rise

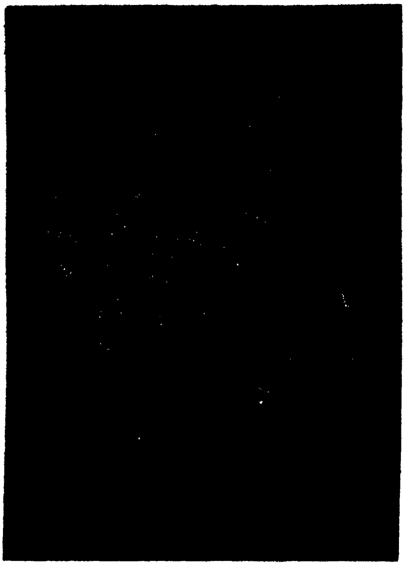


FIG. 122. Xantho-myeloma of the tibia. Note the absence of new bone formation.

to "eggshell crackling." Later the bone gives way and the neoplasm invades the surrounding soft parts. It must be remembered that myelomata may occur in the ribs, or, rarely, in the flat bones, but the commonest situations are the ends of the long bones, the upper end of the tibia or fibula, and the lower end of the femur, radius, or tibia being most often affected.

The *diagnosis* must be made from chronic osteitis, with bone abscess—tuberculous, pyogenic, or occasionally syphilitic, or in the case of the ribs typhoid in origin—or more rarely an endosteal or even periosteal sarcoma, a chondroma, or a bone cyst may present difficulty; the diagnosis is only definitely established by X-ray examination, when the myeloma is seen as a clear area in the expanded and rarefied bone, across which trabeculæ of fibrous tissue can be seen crossing and interlacing in a characteristic fashion. Owing to the effusion in the neighbouring joint, the condition in the early stages may be diagnosed as a synovitis or other disease of the joint.

FIG. 123. X-ray of a myeloma of the humerus.

The *treatment* consists in excision of the tumour, together with the affected area of bone, as merely curetting out the neoplasm and cauterising the bone-cavity is usually followed by local "recurrence," due to the difficulty of completely removing the growth, though this may be tried in cases where a fibrous stroma is present. It must be remembered that severe hæmorrhage may complicate the operation, and that some means, such as bone-grafting, may be necessary to fill in the resulting gap in the bone in order to ensure a useful limb. The results of radium and X-ray therapy are unsatisfactory.

In cases where this is impracticable or unsuccessful, amputation may be advisable.

Diffuse myelomatosis is a rare condition, in which multiple myelomata occur in the bones (in some cases hundreds of small tumours), especially the ribs and small bones of the hands and feet. The condition is diagnosed by X-rays, and associated with the presence of Bence-Jones albumose in the urine, a condition which does not occur in osteitis fibrosa, a disease which may cause difficulty in diagnosis. This condition is due to changes in the bone marrow, and the giant cells are true myeloplaxes.

(B) *Generally malignant* connective-tissue tumours consist of vascular pinkish masses of ill-differentiated and rapidly growing tissue which, from their supposed resemblance to lumps of flesh, have been given the name of sarcomata.

SARCOMA

The cells of these neoplasms appear spontaneously and have assumed the power of unlimited growth and spread indefinitely; thus they are distinguished from the mesodermal cell masses which appear in inflammation (granulomata) as the result of a definite irritation and which cease to grow when that source of irritation is removed, though in both cases the somewhat embryonic connective tissue cells may mature and give rise to fibrous tissue, cartilage or bone.

Sarcomata consist of connective tissue cells of embryonic type which are separated from each other by fine strands of connective tissue and contain many blood spaces; the walls of these blood spaces are very thin, consisting at times of one layer of endothelium, which is often absent, so that the sarcoma cells lie in direct contact with the blood stream, and are thus very liable to be carried away in it to distant parts of the body as metastases, which get held up at the first capillary plexus (that in the lungs); this explains why nearly all *sarcomatous metastases are pulmonary in position* and result from dissemination by the blood stream. Owing to their extreme vascularity sarcomata frequently pulsate, and may present a murmur if auscultated with a stethoscope.

Sarcomata may arise in relation to any form of connective tissue and are, therefore, widely distributed throughout the body, for every organ has in it some mesodermal elements in connection with its blood supply and innervation, even if it is a glandular mass of epi- or endodermal origin. Sarcoma may be said, therefore, to occur in any organ of the body, but, unlike carcinoma, is most commonly met with in infancy or young adult life; it proves rapidly fatal, often from hæmorrhage, which most frequently occurs from the pulmonary metastases, but may occur following ulceration and infection of the primary growth, or its invasion of a large blood vessel; metastases in the brain are sometimes the cause of death.

Dissemination, as already stated, usually occurs by means of the blood stream; the cells of the neoplasm lie in direct contact with the blood spaces, and so are easily washed along the blood stream to the lungs; but rarely dissemination by the lymphatics, with enlargement of the nearer lymph nodes, occurs, and this in spite of the fact that no lymph vessels can be demonstrated in sarcomata. Lymphatic dissemination is frequent in sarcoma of the tonsil, lympho-sarcoma and melanoma, and is also reported in testicular and thyroid tumours; though in many cases some doubt exists as to whether the primary neoplasms have not been carcinomata, as microscopic examination of several so-called sarcomatous growths of the testis and thyroid in museum specimens has shown them to be carcinomata of the spheroidal-celled variety.

The *classification* of sarcomata is usually attempted according to the various types of cells which predominate in any given tumour when examined microscopically, and thus we have the following varieties:—

1. Round-celled.
2. Spindle-celled.
3. Giant- or mixed-celled.

But it must be remembered that in all these types the embryonic cells may mature into one or more forms of definite connective tissue, and that clinically these are rapidly recognised, while the type of cell is not; hence from a practical standpoint sarcomata are classified, irrespective of the type of cells, by the various forms of connective tissue which can be detected in them clinically. Thus we meet with :—

1. Fibro-sarcoma.
2. Chondro-sarcoma.
3. Osteo-sarcoma.
4. Myxo-sarcoma.
5. Lympho-sarcoma.

On microscopic examination each of these tumours is seen to consist of a groundwork of masses of one of the types of cells just mentioned, among which occur blood spaces, into and around which hæmorrhage has frequently taken place ; while in some cases a fine connective-tissue stroma may separate the cells into masses before ramifying between them, this variety resembling a carcinoma on superficial examination, and so earning itself the name of **alveolar sarcoma,** which type is very commonly associated with the presence of melanin granules and occurs in the deeper layers of the skin.

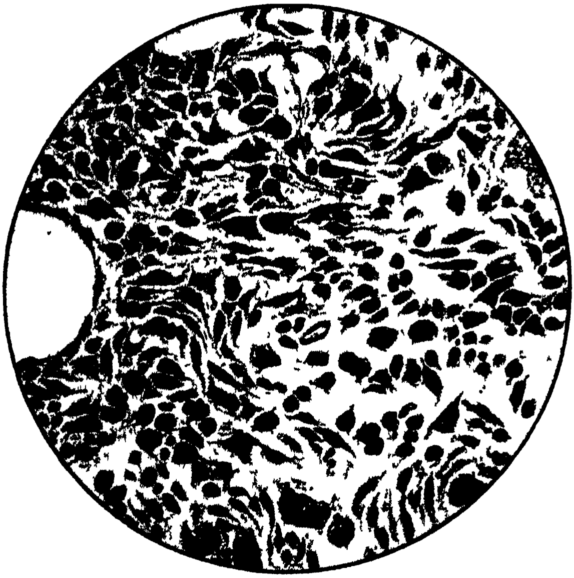


FIG. 124. Round-celled sarcoma (× 200).

(1) **Round-celled sarcomata** may be formed of large or small rounded cells containing an oval nucleus, and these two varieties of this type of neoplasm are usually recognised as separate entities, although there is little or no difference in their malignancy, which is very great. A variety of this type is the **lympho-sarcoma,** in which there is seen a fine reticular intercellular structure lying between the rather loosely packed cells, the whole closely resembling a normal lymph node in appearance.

Chloroma is the name given to certain greenish round-celled masses which occur usually in connection with the periosteum of the membrane bones of the skull in young adults. These neoplasms on section show a grass-green colour, which persists after death, but fades on exposure to light, and microscopically present an appearance similar to a small round-celled or lympho-sarcoma. There are always associated anæmia and blood changes similar to those seen in acute lymphatic leukæmia, so that many authorities regard chloroma as a manifestation of this disease.

The large-celled variety is uncommon, and frequently associated with giant or multinucleated cells.

(2) **Spindle-celled sarcomata** may vary much in consistency, according to the amount of fibrosis among the cells, but a firm tumour is at times even more malignant than a soft one. Such neoplasms usually occur in connection with the fasciæ, tendons or periosteum, and consist of mononuclear spindle-shaped cells of varying size, which may resemble closely fibroblasts in appearance, but usually lack their regular arrangement and tend to be more oval in shape at the extremities. Such tumours contain numerous blood spaces and are very malignant, the more so if the cells are small in size, in which case the neoplasm is usually paler and firmer than is the rule when large spindle cells make up the bulk of the mass.

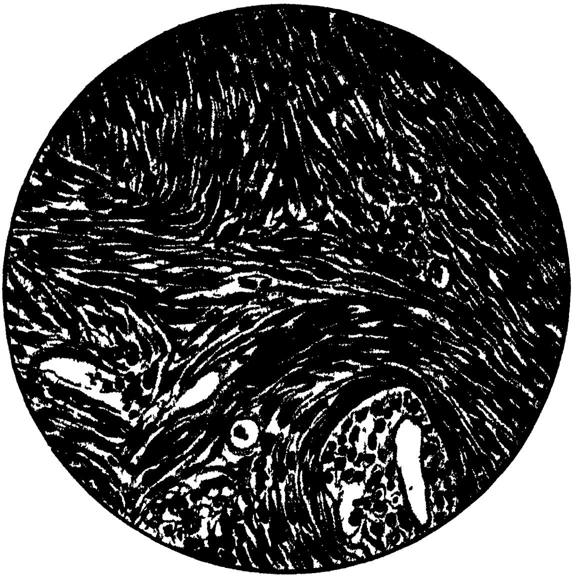


FIG. 125. Spindle-celled sarcoma (× 200).

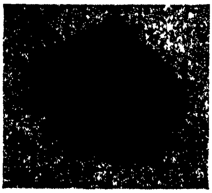


FIG. 126. Melanoma of a vein.

(3) **Mixed-celled sarcomata** are very malignant, and contain ill-differentiated multinucleate masses of rapidly growing protoplasm, which resemble giant cells in appearance, and lead to great confusion between this type of tumour and the locally malignant myeloma. Such tumours may consist of either round or spindle cells, and are not infrequently alveolar in type.

Clinically a sarcoma usually manifests itself as a rapidly growing, spherical or fusiform mass in connection with some connective tissue in a young adult. There is no pain or discomfort until nerves become infiltrated or tissue so involved that they can no longer function and the neoplasm is all too likely to be regarded as an inflammatory mass consequent upon the trauma which so frequently precedes its appearance, a mistake all the more readily made as the extreme vascularity of the tumour leads to reddening and heat in the overlying skin. In the later stages enlarged and engorged veins manifest themselves, the tumour subsequently involving and destroying the skin and fungating, and pulsation or a murmur may be detected in the swelling. Surrounding structures become invaded, hæmorrhages occur in and around the mass, œdema occurs in distal parts, and metastases may be detected in the lungs, where an X-ray film shows them as definite circular shadows, varying in size from a pea to a florin, according to their length of growth.

Spontaneous fracture often occurs in the case of sarcoma of bone, and is not infrequently the first sign of the presence of the growth.

The temperature is at times slightly raised, 99° to 100° F., each night, the maximum rise being recorded about 8 p.m. Should this persist after removal of the primary growth it is a sure indication that metastases exist in the internal organs, and consequently is of grave prognosis.

The *differential diagnosis* lies usually between (*a*) *subacute or chronic inflammation*, from which a sarcoma can be distinguished in the early stages by its more definite edge and the fact that the growth tends to involve the whole length of the structure invaded before breaking through into surrounding tissues, whereas the inflammatory reaction is generalised and ill-defined in outline, and (*b*) *aneurysm*, where compression of the artery stops pulsation in both cases, but re-establishment of the pulse is followed in the case of the aneurysm by immediate return of the pulsation at full strength, whereas in a sarcoma it is only gradually re-established. X-ray films are often helpful in both conditions.

In some cases diagnosis is very difficult, and then exploratory incision should be resorted to, but must be followed immediately by removal if a sarcoma is found.

On section a sarcoma presents a solid flesh-like appearance, and is pinkish or maroon coloured, unless melanin is present, when it is black, and frequently contains cystic spaces due to hæmorrhage. It may contain fibrous tissue, cartilage, bone, etc., and is frequently enclosed in a "false capsule." Some sarcomata appear gelatinous on section.

Treatment is very unsatisfactory, and consists in early and free removal of the neoplasm, together with the tissues invaded. More recently, either implantation of radium or deep X-ray therapy has been extensively used, both of which may work an apparent cure of the primary tumour, but have, unfortunately, less effect on metastases; they have the advantage, however, that extensive and mutilating operations can be avoided. X-ray films should be taken to try to ascertain if metastases are present, especially in the lungs, and should be repeated at regular intervals after removal of the growth, as these frequently manifest themselves subsequently. Recurrence of the primary growth is not commonly the cause of death, but the occurrence of metastases, which usually appear in the lungs and cause death from respiratory failure and hæmorrhage.

Should metastases be present it is often justifiable to remove the primary mass, either to prevent it fungating through the skin or because it is so fungating, or because of pain. *Coley's fluid*, consisting of a mixture of the dead cultures of streptococci and B. prodigiosus in broth, is a treatment based on the knowledge that malignant tumours have been known to disappear after an attack of erysipelas, and is recommended by some authorities. The results are, however, admittedly disappointing, and we ourselves have seen no good from this treatment. Should it be desired to try it, the first injection consists of ♏ ½ of the fluid subcutaneously, and subsequently it is cautiously increased so that too severe a reaction is avoided; the time between doses is determined by the subsidence of the temperature.

The prognosis is always grave and, indeed, almost hopeless, death usually occurring in from three to six months from the time the tumour is first diagnosed. It is doubtful if removal of the growth prolongs life, as death usually occurs rapidly from the metastases.

MIXED EPITHELIAL AND CONNECTIVE TISSUE TUMOURS

TERATOMATA

These are tumours of embryonic origin, containing both epithelial and connective tissue, occurring usually in connection with the ovary or testis, and consisting in portions of a rudimentary dichotomous parasitic embryo. Such parasites may in extreme cases assume human shape, live and project from the body surface of the host, or may be almost independent, as in the case of the Siamese twins, but more often they consist of an inert mass containing tissues of various descriptions, usually teeth, cartilage and hair of a malformed and rudimentary type.

The ovarian dermoid is the commonest variety, and usually consists of a cystic tumour, lined with hair-bearing epithelium, and containing greasy, sebaceous fluid, but sometimes having teeth, mammæ, or even a rudimentary limb projecting into its lumen. Such tumours are most often benign, but may take on malignant characteristics.

Testicular dermoids, which may occur occasionally along the track of the descending testis in the retro-peritoneal tissue, are usually solid and contain epithelial tissue and cartilage. They are usually very malignant, and cerebral metastases are frequent.

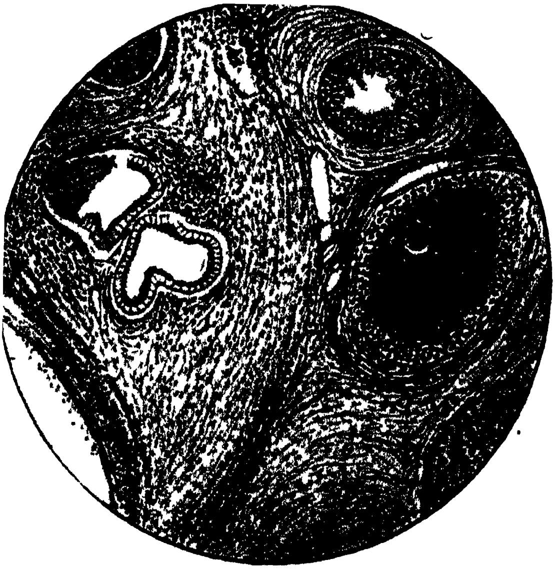


FIG. 127. Teratoma testis (× 65).

Dermoid tumours also may occur in the thorax and the sacral region, and some authorities regard the mixed salivary tumour as being of a teratomatous nature.

Diagnosis usually can be made only by microscopy from sarcoma in the case of testicular tumours and from other forms of cyst of the ovary at operation, by discovering hair and sebaceous contents.

Treatment consists in excision, where this can be done without endangering the life of the host.

CYSTS

The term Cyst is applied to any localised swelling in the body which has a definite lining membrane around a localised collection of fluid.

Such cysts vary much in the tension of the enclosed fluid, but are usually rounded or globular in shape, owing to the equal pressure exerted upon the surrounding tissues in all directions.

Clinically a cyst presents a definite rounded outline, with a more or less definite edge rolling under the finger according to the thickness of the wall and tension of the contents. Fluctuation is present on palpation, but may be hard to elicit if the contained fluid is under great tension, in which case it is useful to apply Paget's test to distinguish it from a solid tumour; in this the hardest part is in the centre of the mass, whereas in a cyst the centre is the softest. The cyst wall is usually fixed at some point to the surrounding tissues, and here the blood supply enters; elsewhere it is separated by a capsule of loose areolar tissue, so that the cyst readily shells out.

Treatment consists in excision of the cyst, especial care being taken to remove the secreting lining membrane so as to prevent recurrence.

Considerable confusion exists as to *classification of cysts*, as various names are given to the same cystic condition, and some varieties of cyst are not so called, but the appended classification will be found sufficient for most purposes:—

- I. **Congenital Cysts.**
  - 1. Dermoids.
    - (*a*) Sequestration-dermoids.
    - (*b*) Tubulo-dermoids.
    - (*c*) Teratomatous cysts.
  - 2. Embryonic.
    - Persistence of embryonic sacs usually obliterated during development.
- II. **Acquired Cysts.**
  - 1. Distension cysts.
    - (*a*) Exudation cysts.
    - (*b*) Retention cysts.
  - 2. Cysts of new formation.
    - (*a*) Implantation cysts.
    - (*b*) Parasitic cysts.
  - 3. Degeneration cysts.

"**Blood cysts,**" so called because the cavity contains blood-stained fluid, may be of traumatic origin, or result from hæmorrhage into a neoplasm or cystic cavity following rapid withdrawal of fluid.

I. CONGENITAL CYSTS

1. **Dermoid cysts** are usually present at birth, but may escape notice until they increase in size from distension owing to exudation into the cavity and growth concurrent with that of the host. Such cysts are lined with epithelium, from which hairs frequently project, and which contains sebaceous glands, the secretion of which distends the cyst cavity.

Such cysts are always adherent to the deeper tissues, but not to the skin.

(*a*) **Sequestration-dermoids** occur, usually near the body surface, along the lines of coalescence of parts of the fœtus; they are thus met with anywhere in the mid-line, and along the lines of junction of the maxillary processes and branchial arches in the face and neck, being most frequently met with about the outer angle of the orbit. The bone may be deficient or pitted beneath cysts of this type, which are often connected to the underlying *dura mater* by a pedicle (see Chapter II., Vol. II.). They are very rare on the limbs, though inasmuch as these are developed from ventrolateral and dorsal axial buds, possibilities of inclusion do occur between the upper and lower segmental portions. Thus these cysts are occasionally seen at the back of the shoulders and on the front of the thigh.

Clinically such cysts give rise to a circumscribed tense swelling, varying in size from a pea to a large marble, which tends to grow as the child gets older. They are fixed to the deeper structures, but the skin moves freely over them.

Treatment consists in complete excision, which is an easy and satisfactory operation.

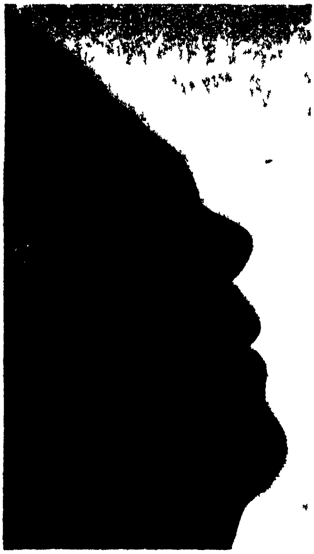


FIG. 128. Dermoid cyst at the root of the nose

(*b*) **Tubulo-dermoids** are caused by the distension of the remains of ducts of fœtal glands, which are normally obliterated, by the secretion from their lining epithelium. The most common situation is in the thyro-glossal duct running from the foramen cæcum of the tongue to the thyroid isthmus; such **thyroglossal cysts** appear, therefore, in the mid-line of the upper part of the neck or at the base of the tongue, and are fully dealt with in Chapter X., Vol. II. Their complete excision is a difficult matter, owing to their extremely thin walls and the difficulty in efficiently removing the complete track.

FIG. 129. Large branchial cyst in neck.

Other situations in which tubulo-dermoids occur are:—

(1) The sacral region in connection with the post-anal gut (neurenteric canal), when they present a cystic swelling lying behind the lower part of the rectum.

(2) In the male in connection with the remains of the Mullerian duct in the prostate and in the hydatids of Morgagni at the upper end of the testis (see Chapters XXI. and XXII., Vol. II).

(3) In the female from unobliterated remains of the Wolffian duct, as cysts of the parovarium and organ of Rosenmuller, and certain cysts at the sides and above the

lateral fornices of the vagina in connection with Gärtner's duct. The common ovarian cyst-adenoma, arising as it does from Pfluger's tubules, also may be regarded as a cyst of this nature (see Chapter XXII., Vol. II.).

(c) **Teratomatous cysts** are common in the ovary (ovarian dermoid) (see Chapter XXII., Vol. II.), but may occur in connection with a teratoma of the testis, especially if situated along the line of descent of the organ (Chapter XXI., Vol. II.).

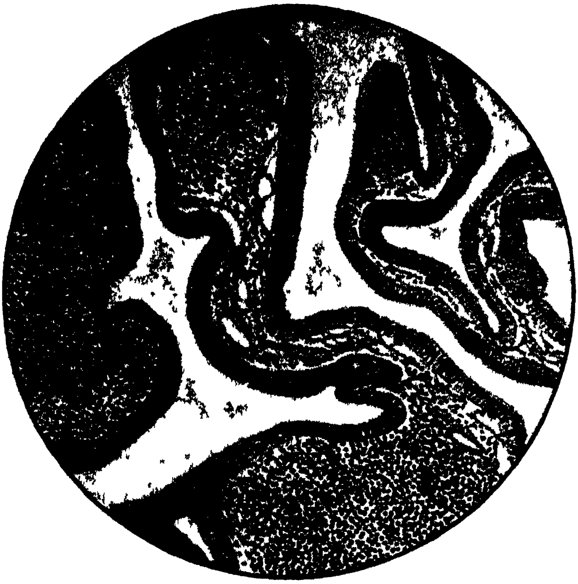


FIG. 130. Branchial cyst (× 55). Note the columnar epithelium.

2. **Embryonic cysts,** from distension of partly obliterated spaces, occur around the scrotum in the processus vaginalis, and result in the formation of the congenital hydrocele or encysted hydrocele of the cord (Chapter XXI., Vol. II.). They may occur rarely in the thorax in the region of the pericardium and ligamentum latum pulmonis.

Cystic hygroma, usually occurring in the neck, also falls under this heading.

II. ACQUIRED CYSTS

1. **Distension cysts** occur (*a*) as the *result of exudation* of fluid into pre-existing spaces, either as the effect of trauma or inflammation, and may occur where any enclosed space exists; if situated in the large serous sacs they are not usually classified as cysts, but as effusions into the pleura, peritoneum, pericardium or tunica vaginalis (hydrocele), meninges (meningocele), joints, bursæ or tendon sheaths, which are dealt with under their appropriate headings.

But in some situations, as in the ovary, where exudation may occur into a Graafian follicle, or in the thyroid, or where owing to abnormal pressure portions of a distended cavity become separated as localised fluid-containing masses, as occurs in Morant Baker's cysts around joints, the term "cyst" is applied to the swelling.

Similar cysts may form around foreign bodies encapsuled in the tissues, or as the result of pressure over exposed bony points (adventitious bursæ), or localised blood cysts may occur in situations such as the sub-arachnoid space over the brain.

(*b*) **Retention cysts** occur as the result of the accumulation of secretion behind an obstruction in or around the duct of a gland, and are well seen in the breasts, where galactoceles and smaller multiple cysts result from various forms of chronic mastitis. The cyst wall is lined with a columnar epithelium, which becomes flattened as the tension increases, and may not infrequently project into the cyst at places forming papilliferous ingrowths (see Chapter XII., Vol. II.).

Similar cysts are met with in the kidney, salivary glands and pancreas.

Treatment consists in excision where possible, together with the affected segment of the gland.

Sebaceous cysts result from the blockage of the duct of a sebaceous gland in the skin, and may occur in any situation, but are commonest on the face, scalp, and neck, where they may be present in large numbers. The contents consist of semi-solid, greasy, sebaceous material, with a stale, unpleasant odour.

Clinically they form rounded, fluctuant swellings varying in size, and fixed to the overlying skin, especially at one point where the blocked gland mouth can frequently be seen as a dark spot. Unless peri-glandular inflammation has occurred the cyst is not attached to the deeper tissues (see p. 247).

The *treatment* consists in removal, either by dissecting out the cyst, or by transfixing and dividing it and pulling out the halves of the wall from the cellular tissue.

Suppuration consequent upon infection is a common complication of such cysts, and the resulting abscess should be treated by free incision with curettage of the lining membrane of the walls. *Chronic infection* may result in much thickening and fibrosis in the subcutaneous cellular tissue, which appears brawny and hard, and may in extreme cases become much hypertrophied ; the skin over it may show patent gland mouths from a state of lymphatic œdema, a condition well seen in rhinophyma.

Following the spontaneous discharge or evacuation of the cyst contents a sinus may form, which will persist, discharging from time to time, until the remains of the cyst wall are completely removed by dissection.

FIG. 131. Sebaceous cyst.

Mucous cysts occurring on the lips, cheeks, etc., are of a similar nature, resulting from the blocking of the mouths of mucous glands.

The treatment consists in cutting away the projecting surface and so marsupialising the base of the gland, which then need not be curetted or cauterised.

2. **Cysts of New Formation.** (*a*) **Implantation cysts** result from portions of the integument being carried into the subjacent tissues, usually as the result of a punctured wound with a blunt instrument, and there developing and forming a cyst lined with epithelium which gradually increases in size as the glands in the lining membrane secrete into it. Such cysts are usually situated about the hands of manual workers, but may occur in other situations and have even been met with in the eye following iridectomy.

Clinically they closely resemble dermoids, being fixed to the deeper tissues and free from the skin; they seldom, however, reach any great size, and careful examination will reveal a superjacent scar and elicit a history of injury. Similar cysts result from the encapsulation of foreign bodies.

Treatment consists in excision.

(*b*) **Parasitic cysts** have been described in Chapter VI., p. 137, and are the alternative stages of various parasitic worms, the commonest being the hydatid cyst and cysticercus cellulosæ. They may occur in any situation, and should they rupture give rise to characteristic urticaria.

Treatment consists in excision where practicable.

3. **Degeneration Cysts.** These occur in neoplasms, either as a sequel of hæmorrhage into the soft tissues (blood cyst), or from degeneration in a tumour with a poor blood supply, when the contents are usually clear myxomatous fluid (colloid degeneration).

Such cysts are of no importance as compared with the tumour in which they occur.

CHAPTER IX

INJURIES AND DISEASES OF THE SKIN AND SUBCUTANEOUS TISSUE

Anatomy. The skin provides a complete epithelial covering to the body, fusing with the mucous membranes of the various internal canals at their outlets, and in certain situations bearing specialised appendages—the nails and hair. Microscopically, it consists of two layers: (1) a superficial cellular layer (*epidermis*), the outermost cells of which are dead and desquamating (stratum corneum); the deeper layers, composed of cells with stellate processes (prickle cells), form the stratum lucidum and the deepest layer, containing more or less pigment, is the Malpighian layer (stratum granulosum), from which the more superficial layers develop. (2) Deep to the epidermis lies the true skin (*corium*), which is rugose, and in the superficial layers of which lie the nerve endings and vascular capillaries; this is known as the papillary region, the deeper reticular layer being composed of loose connective tissue cells and containing a fair amount of fat.

INJURIES OF THE SKIN, ETC.

These may consist of (*a*) **incised wounds**, which may involve only the epidermis (a scratch), or involve the corium and subcutaneous tissue in addition (a cut). The wound " gapes " according to its depth, length and situation, and may need sutures to approximate its edges and retain them in position. The bleeding from such lesions is slight and easily controlled by pressure; some antiseptic, such as tincture of iodine, may be employed as an immediate dressing. For fuller description see Chapter IV., p. 39.

(*b*) **Lacerated wounds**, when large areas of skin and deeper tissues may be avulsed (Chapter IV., p. 38).

(*c*) **Bruises and contusions** follow blows from blunt instruments or falls on hard surfaces, and in adipose persons or in those regions where bursæ, etc., exist in the subcutaneous tissue, the extravasated blood may collect as a localised fluid swelling (*hæmatoma*). The affected area is swollen, tender, may fluctuate, and ultimately shows discoloration.

Treatment consists in the application of cold compresses or evaporating lotion under a firm pressure bandage. Aspiration under careful aseptic precautions should be resorted to after twenty-four hours if a hæmatoma of any size is present, as suppuration following infection of the clot is a not infrequent complication; see Chapter IV., p. 38.

(*d*) **Burns and scalds** are usually limited to these tissues, and are fully dealt with in Chapter IV., p. 58.

For **affections of scars**, see Chapter II., p. 24. **Pigmentation** may occur in the scars resulting from old-standing ulcers (other than gummatous ulcers where the scar is papery white), changed blood pigment remaining among the fibrous tissue in the areas where capillary hæmorrhages have occurred; this leads to pigmentation, which is at first purplish in colour, but later dark brown as hæmatoidin is formed.

Surgical emphysema is a condition in which air or gas present in the connective tissues gives rise to a typical soft crepitating and crackling on handling the affected part. It may be very extensive, spreading along fascial planes, but is not usually dangerous unless causing pressure on vital organs, the exception being when the gas is due to infection by gas-forming anaerobic bacteria (Gas Gangrene, Chapter VII., p. 164), primarily of injured muscle, a condition which, unless promptly treated, is rapidly fatal.

Surgical emphysema may result from :—

1. Injury to underlying air-containing structures, as
   - (a) *The trachea* after tracheotomy.
   - (b) *Fractured ribs* penetrating the lung.
   - (c) *Rupture of the colon* or bowel (extra-peritoneal).
   - (d) *Fractures of the bones of the skull* involving air sinuses.
   - (e) *Ruptures of the lung or bronchus.*
2. The presence of free oxygen in the tissues around a wound treated with hydrogen peroxide.
3. *Infection* with gas-forming organisms :—
   - (1) From extra-peritoneal wounds of the colon or bowel (auto-infection).
   - (2) From wounds contaminated with gas-forming anaerobes (gas gangrene).
4. Air may be sucked into the tissues around wounds in certain situations, such as the neck, and abdominal wall, by the respiratory movements (see also Chapters X., XI. and XIII., Vol. II.).

Treatment. In most traumatic cases no special treatment is indicated, except avoidance of acts, such as coughing or nose-blowing, likely to force more gas into the tissues, but in infective cases (and those due to trauma of the bowel) prompt incision and drainage with cleansing of the area is necessary to save the patient's life.

Blisters result from serum or blood accumulating under the horny layers of the epidermis, and are frequently seen as the result of injury ; they may be clear if containing serum, as after burns or crushes, or as the result of friction, as from walking ; or black or dark blue in colour, as in the blood blisters frequently seen when a fracture of a bone has occurred in the neighbourhood. Such blisters may become infected, when the fluid becomes purulent, and they then constitute, if on the fingers or toes, a subcuticular whitlow (see p. 229). The condition is easily recognised.

Treatment. (a) Serous blisters should be incised, the skin removed and a dressing of 1 per cent. aqueous picric or sterile paraffin applied. The prophylactic treatment of blisters on the feet consists in wearing well-fitting boots, seeing that the socks are free from rough darns or rucks, and hardening the feet with weak formalin or spirit. Daily washing and powdering the feet with starch and alum are also valuable as preventing " sweating."

(b) Blood blisters after an injury are usually a sign of serious bone injury, and so call for no special treatment *per se.*

DISEASES OF THE SKIN, ETC.

Hypertrophy or overgrowth of the epidermis, with great thickening of the horny layer, may result from continued friction or pressure over any area ; such a thickened and indurated region of skin is a *callosity*, and may be met with on the fingers of manual workers, and on the heads or shoulders of porters. The condition, although often unsightly, calls for no special treatment, but not infrequently an *adventitious bursa* (Chapter XIII., p. 401) develops beneath the area, and if inflamed or infected will cause a painful fluctuating swelling calling for treatment, which consists in excision, or incision and drainage if the infection is acute. It is worth mentioning the very intractable condition not infrequently met with over the tendo Achillis in young women as the result of friction of the shoe-top if the heels are high. Treatment in the early stages consists in lowering the heels, but often it is necessary to wear boots for six months to allow the bursa and callosity to subside.

A corn results from neglect or improper treatment of a callosity, the centre of which forms a hard plug which grows down and presses on the papillæ of the underlying corium, causing them to atrophy, and so forming a cup-shaped depression, the cuticle around which becomes hypertrophied and grows up, partly obliterating the hollow. It is the presence of this horny plug which constitutes the difference between a true corn and a callosity, and on its complete removal depends the alleviation of the pain and discomfort which result from its pressure on the nerve endings of the papillæ, the appearance of the removed mass giving it the popular name of the "root" of the corn.

Such corns usually occur on the toes, soles or sides of the feet as a result of wearing ill-fitting boots, especially if these be tight, and the callosities are improperly treated, but they may occasionally be met with on the fingers and hands.

Two varieties of corns exist clinically: (1) the hard; (2) the soft.

1. *Hard corns* occur in dry situations such as the outer side of the little toe and consist of a keratinised mass of epithelium, in the centre of which is seen a hard, dark and solid plug; the whole is usually raised and conical.

2. *Soft corns* occur in moist situations, such as between the toes, and consist of raised masses of sodden white epithelium.

Both conditions are very painful, especially in damp weather and after walking. Not infrequently bursæ develop beneath the corns and are likely to become infected and suppurate, when great pain results, a condition which may be followed by sloughing and cure of the corn.

The *treatment* is the same for callosities and corns, and consists essentially in removing the source of irritation or pressure, as by wearing well-fitting boots and socks. The corn may be pared carefully daily, without causing bleeding, and then the area painted with the following mixture of salicylic acid and collodion, which destroys the epidermis, and loosens the central plug, which ultimately comes away.

℞ Salicylic acid	grs. lx
Collodion flexile	ad ℥i

This is applied with a brush twice daily after paring the corn. This paint needs to be kept tightly stoppered in a cool place to prevent evaporation of the ether.

Radium applied to the surface of the corn in a flat applicator, dosage about 10 mmg. for half hour, gives excellent results in the vast majority of cases, especially with soft corns.

In rare cases excision and suture are advisable.

In the case of patients with impaired circulation, great care is necessary in the treatment of corns, as the reaction resulting from infection, or sometimes even called up by treatment, is a frequent cause of the onset of senile gangrene (Chapter VII., p. 156), or, again, a perforating ulcer may result (p. 248).

INFECTIONS OF THE SKIN

Infections may be due to (1) pyogenic organisms, in which case the resulting lesions may be (*a*) localised, when boils, abscesses or carbuncles result, or

(*b*) generalised, when erysipelas or cellulitis will occur; or they may be due to (2) specific infections, such as—(*a*) Tuberculosis,
(*b*) Syphilis,
(*c*) Parasites,
(*d*) Toxæmias.

(1) **Pyogenic infections** are discussed in Chapter V., but will be briefly recapitulated.

(*a*) *Localised lesions* are in most cases due to the presence of the staphylococcus. A **boil** results from the infection of a hair follicle and presents a conical red and painful swelling, from the centre of which a hair protrudes; around the base a greyish area shows as pus develops and a slough forms.

Treatment consists in protecting surrounding follicles by application of mercurial ointment, incising the boil and removing the slough, afterwards applying a dry sterile dressing.

An **abscess** occurs as the result of the localisation of an infection by the inflammatory reaction of the tissues, and consists of a liquefied area of dead tissue, leucocytes, plasma and bacteria, surrounded by a wall of living leucocytes, which in chronic cases lie in organised granulation tissue; care must always be taken not to break down this barrier by such acts as " squeezing out the pus " from an incision. The area around the abscess cavity shows all the signs of acute inflammation, pain, redness and swelling, there is tenderness on pressure, œdema, and fluctuation usually can be obtained in subcutaneous abscesses. In abscesses secondarily developed in chronic pyæmia no signs of active inflammation are usually to be observed.

Treatment. In the early stages this consists in rest, and means to promote congestion in the part and promote resolution, but so soon as pus is formed, when the pain becomes throbbing in character, incision and drainage are required. It must be borne in mind that unless tension exists around the abscess, a very large collection of pus may be present in the subcutaneous tissues, little or no pain being complained of.

WHITLOWS

There is a special name, whitlow, given to those abscesses occurring in the structures of the fingers and toes, and although strictly speaking only some of the varieties come under the heading of skin and subcutaneous tissues, it is convenient to discuss all types here.

A **whitlow** may be defined as an abscess occurring in the digits, and usually consequent on infection of some trivial punctured wound or abrasion, such as a pin-prick or scratch. The resulting abscess is usually classified according to its situation in the tissues, and thus the following varieties of whitlow are met with:—

(1) **Subcuticular whitlow.** This is a purulent blister occurring between or deep to the stratified cells of the stratum corneum of the epidermis. It is not painful or dangerous and calls for no other treatment than the complete removal of the dead cuticle overlying the blister and the application of a sterile dressing. Similar treatment is necessary for the analogous condition met with in the skin of the palm of the hands and feet as the result of friction and infection from unaccustomed work or walking. One variety of subcuticular whitlow calling for special mention is that occurring under or around the nail (see p. 249), which, if the pus is under the nail, calls for the removal of the nail to relieve the pain and effect a cure.

(2) **Subcutaneous whitlow** occurs in the subcutaneous fat. The finger is noticed to feel tender and painful, with a localised area of redness and tenderness. The discomfort is less when the hand is held up or supported in a sling. Later the signs of an abscess develop and call for incision to let out the pus and relieve the pain and toxæmia consequent on the presence of the fluid and micro-organisms under tension.

In the *subcutaneous fat of the terminal phalanges* the condition is of serious import, owing to the anatomical arrangement of the dense fibrous septa radiating from the bone to the skin. Whitlow is particularly prone to occur here, as the terminal phalanx is especially exposed to slight trauma which often escapes notice till infection has occurred. Inasmuch as the vessels run longitudinally in the lateral spaces, infection here is very liable to obliterate these vessels early, owing to the tension between the fibrous walls of the space, and so cut off the blood supply to the shaft of the bone (*not* the epiphysis, which gets its supply from the circulus vasculosus at the interphalangeal joint, which thus escapes infection), so that necrosis of this part of the phalanx is very liable to occur rapidly as a secondary result; this condition is very liable to be mistaken for a primary subperiosteal whitlow (p. 233), an uncommon occurrence.

Clinically, the pulp of the phalanx is tense and tender, there being but little visible swelling owing to the fibrous septa, though the skin is red and hot, and great pain is experienced, often of a throbbing nature, which shows that pus is present under tension.

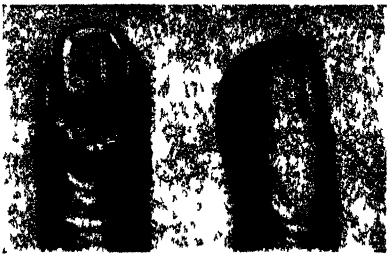


Fig. 132. Showing A, incisions for dealing with suppuration beneath the nail bed. B, incision for incising subcutaneous whitlow

Treatment consists in *prompt* incision, so as to save the bone, and that without waiting for pus formation. In order to open up adequately the spaces, far more than to save a central scar, an incision is made on one or both sides of the finger, according to the extent of the infection, the knife being passed well into the pulp, so as to divide the septa freely and so relieve tension on the vessels supplying the bone. There is *no* need to carry the incision across the end of the finger, where the presence of a scar of necessity must be a disability on subsequent use. After-treatment consists in the use of frequent baths and application of dry sterile or saline dressings. Should necrosis of the phalanx have occurred, the sequestrum should be removed as soon as it is loose, though in cases where superficial necrosis on one side alone has taken place, simple curettage is often sufficient. In no case should the joint be opened, nor the condition be neglected till button granulations project from a swollen digit, as in Fig. 134.

Shirt Stud Abscess. Not infrequently an abscess occurs under the horny palmar epithelium in labourers, which is found on incision to pass back through a narrow opening into the subcutaneous tissues; sometimes at the metacarpal heads to those of the dorsum of the hand across the finger web. In such cases the deeper collection of pus must be efficiently drained.

Another variety of subcutaneous whitlow occurs in the *cellular tissue of the palm* deep to the tendon sheaths and in front of the metacarpals, potential spaces described by Kanavel as the *thenar and palmar spaces.*

Infection in the thenar space, which lies in front of the second phalanx and first interosseous, usually follows infection in the cleft between the thumb and index finger, and so is seen more often in the right hand and in manual workers. *Clinically* a tense swelling occurs in the deeper part of the first interosseous cleft, and the pus tends to point to the radial side of the index finger. There is little pain, and movements, though restricted, are not painful.

Treatment consists in prompt evacuation of pus to save infection of the superjacent tendon sheath. In order to prevent a scar on the palmar surface or web, where it would interfere with the grip, a longitudinal incision is made on the dorsum, and an artery forceps passed into the first space across the palmar aspect of the metacarpus, when pus is soon evacuated. If necessary, a fine rubber drain may be inserted, but this is seldom necessary if the incision is adequate.

The palmar space lies on the palmar aspect of the third and fourth metacarpals, and pus collecting in it points at the web between these digits, on the dorsal aspect of which an incision should be made to evacuate it.

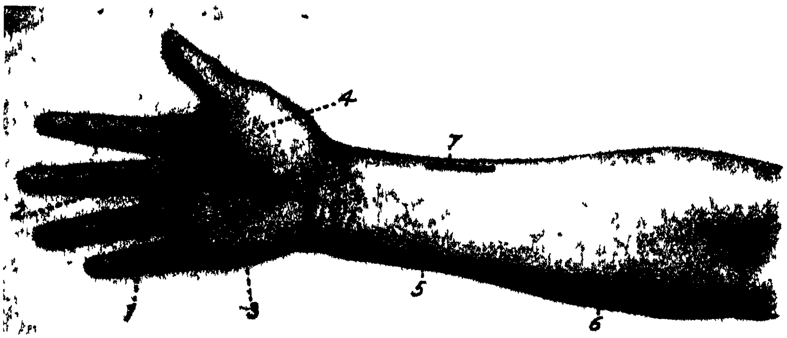


FIG. 133. Incisions for suppuration in: 1, Thecal whitlow; 2, Thecal whitlow with extension into palm; 3, Ulnar bursa (flexor tendon sheaths); 4, Radial bursa (flexor longus pollicis); 5, 6 and 7, Infection spreading up the forearm.

To the careful observer there is small likelihood of confusion of this condition with its localised redness, and œdema only on the ulnar side of the dorsum, with infection of the tendon sheaths in the palm.

(3) **Intrathecal whitlow** is a serious condition, the infection occurring deep to the dense fibrous sheaths of the flexor tendons, which, it must be remembered, do not extend beyond the extreme base of the terminal phalanges. The tendon and tendon sheaths therefore become early involved, and unless the tension is promptly relieved by free incisions through the fibrous theca, sloughing of the poorly nourished tendon, or spread of infection up the sheaths into the palm or sole, a very serious complication, will occur rapidly. This condition is particularly liable to occur from the thumb and little finger, where the sheaths are continuous across the palm into the forearm, respectively constituting the *radial* and *ulnar bursæ* of Kanavel.

Clinically the condition is manifested by very severe pain, more marked on pressure over the fronts of the phalanges, where the fibrous sheaths keep the pus under tension, the finger being slightly swollen and acutely tender, and held immobile in a semi-flexed position; all attempts at moving it cause excruciating pain, which is not infrequently referred up the forearm and may cause the patient to vomit. In the case of the index, middle and ring fingers œdema appears at the base of the finger in the palm just above where the fibrous tendon sheath terminates and may give rise to an erroneous diagnosis of palmar whitlow.

Treatment consists in prompt incision into the thecal sheath, even if the presence of pus cannot be ascertained definitely; the incision should, if possible, be on the side of the finger and only along the central parts of the phalanges, but in front of the lateral vessels and nerve, thus enabling adequate drainage to be secured, without completely destroying the theca and so releasing the tendon from its restraining tunnel in front of the joints; also preventing a scar in the mid-line, which always causes pain on gripping.

FIG. 134. Typical bulbous appearance of the finger-end with sequestrum in situ after subperiosteal whitlow.

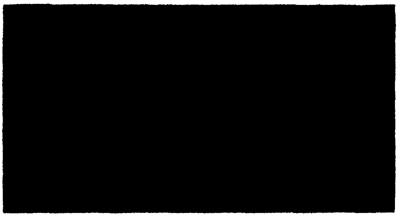


FIG. 135. X-ray picture of diseased finger shown in Fig. 134.

Subsequent treatment involves warm baths, with sterile dry dressings in the intervals, the baths being given for about twenty minutes every four or six hours.

(*a*) Should infection of the tendon sheaths of the palm or forearm occur (Chapter XIII., p. 391), it must be dealt with promptly by free incision and bathing. In those cases where the *palmar sheaths* are infected, the whole hand is swollen, and often the palm is actually bulging and tense, while swelling is frequently present in the front of the forearm. Owing to the density of the palmar fascia, the skin and subcutaneous tissue of the palm are not œdematous, but there is intense œdema of the whole of the dorsal aspect of the hand, which region is not tender on pressure. The palm is acutely tender and very painful, so that the patient, who has marked constitutional signs, may vomit. The fingers are held semi-flexed and motionless, and any attempt at passive or active movement causes excruciating pain.

Treatment to be of any use must consist in prompt and free incisions to evacuate pus, and so relieve tension on the tendons, which otherwise will slough.

(*b*) If infection comes from the thumb, *i.e.*, is in the radial bursa, an incision should be made along the radial side of the proximal phalanx and continued across the distal curve of the thenar eminence into the palm and to the wrist; this must be deep enough to open the tendon sheath in its whole length.

In infection in the ulnar bursa, the incision starts between the fourth and fifth fingers, and is carried straight up to the wrist, opening the sheath through the palmar fascia.

In either case *no* tubes will be required, as drainage is free. Baths, and saline or dry dressings should be used, and the patient encouraged to move the fingers and wrist from the first.

(*c*) When infection has *extended to the forearm*, the pus lies at first between the muscles and interosseous membrane, though if not evacuated, it tracks among and into these former, and a purulent myositis results; this is a very serious and disabling complication which should never occur.

Clinically, added to the signs of infection just given above, there is marked tenseness and swelling of the forearm, above a band of tissue normal in appearance and corresponding to the attachments of the anterior annular ligament in front of the wrist. There will be pain up the arm, and involvement of the axillary glands, often progressing to abscess formation, will be present.

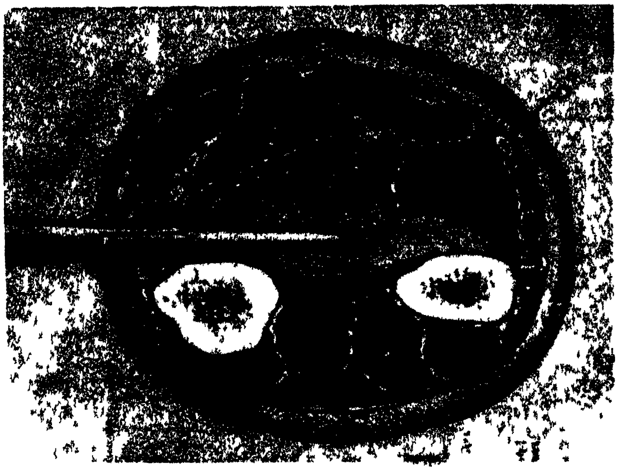


FIG. 136. Transverse section of a forearm showing pus extended from the sheaths in the palm, lying deep in the muscles, and approached by an incision on the ulnar side, through which an artery forceps has been passed into the abscess. A and B, ulnar nerve and artery; C, median nerve; D, radial artery.

Treatment consists in an incision along the anterior aspect of the ulna or radius, according to the side affected, extending up the lower third of the forearm, and in extensive cases supplemented by a similarly placed incision in the upper third; this incision penetrates the deep fascia, and then pus will be evacuated. The vessels and nerves lie anterior to the pus and incisions. Occasionally it may be necessary to incise on both lateral borders of the forearm and pass a forceps across to break down septa.

It is unnecessary to leave tubes in, and treatment follows the lines laid down above.

Should purulent myositis be present, multiple small incisions should be made in addition to those described.

The prognosis of thecal whitlow is never very good, as some adhesions nearly always occur in the tendon sheath, with consequent stiffness and impairment of movement, while sloughing of the tendon is frequent; the former can be to some extent dealt with by early movement if the infection has been mastered.

(4) **Subperiosteal whitlow** is in reality a suppurative osteitis, and the abscess occurs deep to the periosteum of the phalanges or in their medullary canal. The infection, which is not common, may result from a deep prick from a needle or be blood-borne, when it usually occurs at the base of the phalanx near the epiphyseal line, especially in children, and necrosis of the phalanx frequently follows.

It must be remembered that necrosis of the terminal phalanx, distal to the epiphysis, is common in neglected cases of subcutaneous whitlow of the terminal joint, as a secondary result of the pressure cutting off the blood supply to the bone (p. 229).

Clinically the onset is usually sudden and there may be shivering or vomiting. The finger is extremely painful and tender, but in the early stages looks normal and can be moved without any additional pain (thus differing from the condition met with in the thecal variety of whitlow). Later the finger becomes red and swollen, and the pus will gradually work its way to the surface, but often may infect tendon sheaths and joints in so doing. Necrosis of the affected bone not infrequently results, and when it occurs gives rise to a very characteristic pulpy swelling of the digit, especially at its tip (Fig. 134).

Treatment consists in an early incision down to the affected bone; this should be made on its lateral aspect (so as to avoid the tendon sheath and a mid-line scar) and must go through the periosteum so as to give exit to exudate, which in the early stages may not be purulent. If this is done early necrosis is frequently avoided, but should it occur, as will be shown by a persisting sinus, generalised swelling of the affected segment and the development of a "button" granulation (see Chapter XVIII., p. 537), then X-ray photographs should be taken and the dead bone located and removed. Baths and dry sterile dressings are the best after-treatment, but this form of whitlow often takes long to heal; if necrosis occurs deformity will result, and subsequent amputation may be necessary.

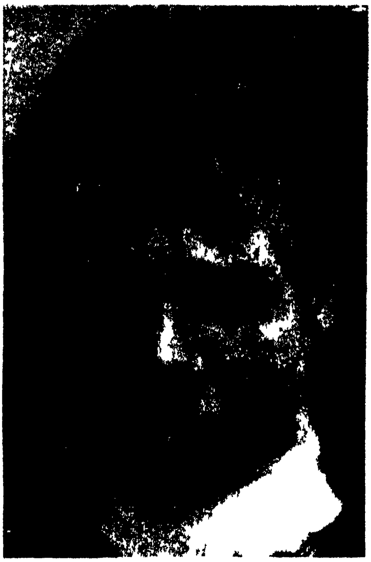


FIG. 137. Impetigo contagiosa.

Impetigo contagiosa is a disease which, unlike boils or abscesses, is seldom of staphylococcal origin, and usually results from a streptococcal infection of a cuticular abrasion. It is commonly met with on the face or knees of young children, but may occur in any situation and be very widespread and severe in neglected cases. As usually seen, impetigo consists of three or four dry yellowish-brown flattened scabs, situated on a slightly reddened area of skin; removal of these scabs reveals an irregular superficial ulcer deep to each, from the granulations on the floor of which a sticky seropurulent exudate rapidly dries to form a new scab.

Treatment consists in regular removal of the scabs by washing in hot water and soft soap and the rubbing in of some antiseptic ointment, of which ung. hydrarg. ammon. dil. is perhaps the most efficacious.

Thickened nodules (painful subcutaneous nodule of Wood), consisting of fibrous tissue and granulations, may occur in the subcutaneous tissues as the result of inflammatory reaction of the structures to the presence of foreign bodies of various descriptions, or to mild infective foci; such are sometimes met with after influenza, when they may be multiple and cause some pain.

The masses vary in size and may or may not be multiple or painful; they are invariably fixed to the surrounding tissues and may have a surprisingly definite edge. The history or X-ray picture may show the presence of a foreign body, or the history of a recent attack of influenza may be obtained.

Treatment consists in excision if a foreign body is present, but the nodules following influenza are best left alone, when they soon disappear.

The solitary mass around a foreign body may be mistaken for a chronically inflamed sebaceous cyst or adventitious bursa.

Carbuncle, as already pointed out (Chapter VII., p. 163), is one variety of infective gangrene, the infection (most often *Staphylococcus aureus*) usually being blood-borne, though it may follow bruising of the subcutaneous tissues, especially in debilitated or diabetic patients. The lesions may occur anywhere in the subcutaneous tissue, but are commonly met with on the back of the neck and back. If occurring on the face or lips the prognosis is very bad, a fatal result being likely.

Though included among the localised infective lesions, a carbuncle has often no clearly defined margin, and even if a line of demarcation has formed there is frequently a tendency for the infection and gangrene to spread beyond it, so that the condition in some ways resembles a cellulitis, and indeed bears much the same relation to a boil as does cellulitis to an abscess.

Clinically the infection leads to thrombosis of the vessels in an area of subcutaneous fat, with the formation of a greyish pultaceous slough, the tissues around which are congested, brawny, red and œdematous, and painful and tender. The skin over the dead tissue, being deprived of its blood supply, turns a purplish colour and then necroses, becoming insensitive, and showing numerous small sloughs, which separate, leaving a series of sinuses from which issues a saniopurulent discharge containing shreds of slough. The area affected may vary in size from an inch to a foot square or rarely be over this size. There is serious constitutional disorder, the temperature being raised, the tongue dry and furred, the bowels costive, and toxic glycosuria frequently present. On the lips and face carbuncles are specially dangerous.

Treatment consists, if the position and localisation of the carbuncle allow and its size does not preclude it, of excision of the whole area, so that healthy bleeding tissue is exposed, which is packed with camphenol for forty-eight hours and then encouraged to granulate. If this is impracticable, the dead skin should be cut away and dressings of lot. sodæ chlor. applied to encourage separation of the slough, which may be further aided by the use of vaccines, these, in addition, increasing the patient's general resistance. When on the face no active surgery should be done.

It is essential to keep up the general health; a generous diet should be given and alcohol used unstintingly, port or sherry being a palatable form in which to administer it.

(*b*) *Generalised infections* are usually due to streptococcal invasions, though in certain cases where tissue resistance is low, staphylococci may produce such lesions.

Erysipelas, as already described (Chapter V., p. 72), is due to infection of the lymph spaces of the epidermis with streptococci, and clinically presents a diffuse and often rapidly spreading area of reddened and somewhat raised skin, the edge of which is markedly irregular in outline, resembling somewhat the "west coast of Scotland." There is a sensation of itching and smarting, and in some cases, particularly in old persons, generalised toxæmia may be severe.

Treatment consists in the application of some dehydrating agent, such as a saturated solution of hypertonic saline or magnesium sulphate, or strong antiseptics such as ichthyol ointment or brilliant green and the administration of sulphanilamide by mouth.

Cellulitis is a generalised and spreading infection of the deeper layers of the skin and the subcutaneous tissues, which show all the signs of inflammation and are swollen and infiltrated with a seropurulent exudate rich in micro-organisms and leucocytes, the fluid lying among the tissue cells. The affected area is therefore red, swollen and painful, and the lymphatics leading from it often show as red streaks (lymphangitis); neighbouring lymph nodes are enlarged and tender and not infrequently suppurate. As already described on p. 71, the tissues make repeated but unavailing attempts to localise the infection, which spreads till localisation is affected. Thrombosis may occur in some areas, and the skin over these then goes black and sloughs.

Treatment in the early stages, and indeed unless toxæmia manifests itself to any marked degree, consists of rest, warm baths and the application of Klapp's suction bells or Bier's hyperæmia to increase the blood supply and the giving of sulphanilamide in all cases of streptococcal origin. If, however, toxæmia is marked or a suppurative focus is present, adequate incisions, followed by warm baths, are urgently indicated. Difficulty may be met with in diagnosing cellulitis from gout and erythema nodosum or multiforme.

Spreading subcutaneous gangrene as described in Chapter VII., p. 163, may occur around empyema, appendix and other infected wounds, and is analogous to the hospital gangrene of our forefathers; it is extremely painful and spreads until free excision of the infected subcutaneous tissue is carried out, when rapid healing ensues.

(2) **Specific infections** are mostly those of the infective granulomata (Chapter VI., p. 101).

(*a*) **Tuberculous lesions** may be due to infections from without or be secondary to extensive lesions elsewhere; it is with the former type of case that we are chiefly concerned here.

Firm cutaneous nodules may be met with on the face, forearms or legs of children and more rarely of adults; they are not infrequently multiple, and if left tend to break down, forming a typical tuberculous ulcer (Fig. 66 and p. 151). In appearance they present an oval nodule, fading gradually into the surrounding tissue and fixed in the skin, which is rather thick and bluish over the affected area; the colour does not entirely disappear on pressure. Such nodules not infrequently occur on the calves of young women and girls, when both legs are affected, though one usually earlier and more than the other; ulceration almost invariably occurs, and the condition is known as **Bazin's disease.**

Treatment consists in excision of the nodules with the whole thickness of skin, and suture; if, however, the nodules are very numerous, as in Bazin's disease, X-ray or ultra-violet ray treatment may be tried, but when, as is often the case, the disease is not amenable to this form of treatment, excision and Thiersch skin grafting should be practised

Care must be taken to distinguish Bazin's disease of tuberculous origin from similar conditions due to chronic pyogenic or gummatous infiltration, erythema nodosum, and self-inflicted rashes in neurotic subjects.

Tuberculous ulcers (p. 151), with their undermined œdematous edges and pale flabby granulations, may result from the breaking down of one of the above-mentioned cuticular nodules, or follow the breaking down of the infected skin over a disintegrated tuberculous lymph node, or the infection of a cut with the specific bacillus.

Treatment consists in excision where possible, care being taken that in cases arising in connection with broken-down lymph nodes, the remains of the gland and all caseous material are removed completely. Suture is then performed, and healing usually occurs *per primam.* In those cases where excision cannot be practised, X-rays and ultra-violet rays may be employed and tuberculin administered (p. 105), but these methods are not so satisfactory.

Lupus (Chapter VII., p. 151) is due to the deposit of "tubercles" in the lymph spaces of the skin ; it is a chronic disease occurring in the cutaneous, and also mucous, surfaces of the body, commencing often in childhood, spreading slowly, and although locally destructive, seldom dangerous to life. The lesions appear as small, semi-translucent, yellowish brown "apple jelly" nodules, which coalesce and, as the lesion spreads, usually resolve in the centre with the formation of areas of scar tissue ; they may break down and ulcerate, however, when a very callous superficial lesion results. If left untreated, gross destruction of tissue and deformities from scarring will result. The glands are seldom affected.

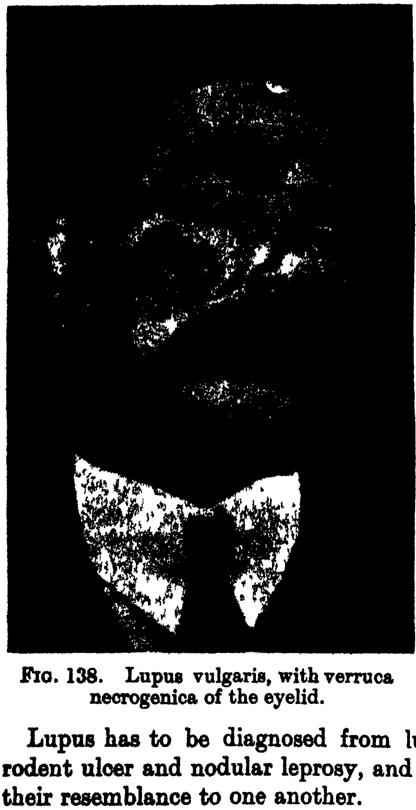


FIG. 138. Lupus vulgaris, with verruca necrogenica of the eyelid.

Treatment consists, when possible, in excision of the lesions, together with the whole thickness of the underlying skin, and suture or Thiersch grafting. There is a tendency for keloid to develop in the scars, but the result is usually satisfactory. When excision is not possible, very thorough curetting may be tried, or application of X-rays or ultra-violet rays. A virulent form of epithelioma is prone to develop in old-standing lupus scars.

Lupus has to be diagnosed from lupus erythematosus, syphilitic lupus, rodent ulcer and nodular leprosy, and these conditions may be very close in their resemblance to one another.

Verruca necrogenica ("butcher's wart") is a hypertrophic granulating mass, resulting usually from infection of a wound with tubercle bacilli, but it may occur in the middle of a lupoid lesion. The lesion is usually on the forearm or face and presents a warty mass, largely covered with scar tissue; treatment by excision gives good results.

(*b*) **Syphilitic cutaneous lesions** may occur in any stage of the disease (Chapter VI., p. 108).

(*a*) The primary sore, if near the genitals, is usually indurated, but elsewhere may merely present the appearance of an indolent fissure; the neighbouring lymph nodes are always enlarged, hard, painless, discrete and mobile.

(*b*) Secondary rashes of a variety of types may be met with; they do not itch and are usually denser on the abdomen and flexor surfaces of the limbs, being often more obvious if looked at from a distance.

(*c*) Tertiary (gummatous) lesions may occur as typical rounded gummatous ulcers, with deep clean-cut sides leading down to a washleather slough or red granulations, in the subcutaneous or deeper tissues; or they may manifest themselves as a chronic infiltration of the skin, with ulceration which has a crenated serpiginous outline, the so-called *syphilitic lupus*. The condition tends to heal, and even disappear, and later remanifest itself; also to spread more rapidly and be more destructive than lupus of tuberculous origin.

Bone is destroyed by syphilitic lesions, but not by tuberculous lupus, although both will destroy cartilage, as in the nose.

Leprosy is only occasionally met with in this country (see Chapter VI., p. 98).

(*c*) **Parasitic lesions** may be the result of the formation of the cysts of the hydatid or of cysticercus cellulosæ in the subcutaneous tissues (Chapter VI., p. 139). Such conditions are rare, and the resulting cyst probably will be diagnosed as of sebaceous origin unless microscopically examined after removal.

Certain skin lesions also may result from the irritation of parasitic insects, such as fleas, bugs and lice of various descriptions, where an irritative erythematous or urticarial weal follows the bite and salivation of such an insect, and where, moreover, scratching of these lesions with dirty nails may result in extensive superficial septic abrasions.

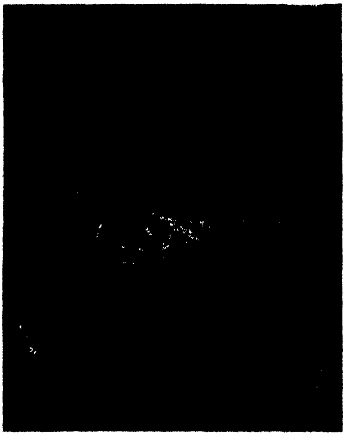


FIG. 139. Chancre of lip.

Scabies, resulting from the burrowing of the itch mite in the soft skin of the wrist, elbow and between the fingers, may cause extensive septic lesions consequent on the scratching called forth by the severe itching, and the septic condition may indeed mask the scabies.

Treatment in the former class of parasitic lesions consists in cleansing and disinfection of the skin and clothing and the application of mercurial ointments, of which the best is ung. hydrarg., which, however, must be used cautiously. In cases of scabies, sulphur ointment should be substituted or the skin painted on two successive days with benzyl benzoate when the sepsis has abated, and a general cleansing of clothes, linen, etc., undertaken.

Tinea (ringworm) is an infection of the superficial epithelium with a fungus, which tends to spread in a circle from its original point of infection; hence the name ringworm. Several lesions may be present in the same individual, usually a child, and as the condition is very contagious, several members of the same family or school are usually affected. Two varieties of parasite are recognised: (1) the one commonly met in the hairy scalp has very small spores, and gives rise to Tinea tonsurans; (2) the one met with usually on the skin elsewhere, but occasionally on the scalp, has larger spores, and causes Tinea circinata.

Microscopic examination of the scrapings from an affected area shows the matted branching hyphæ of the mycelium, and masses of spores, which are particularly abundant in the dead and disintegrated hairs in the region. Owing to the destruction of the hairs, these break off short, and in hairy regions there is a rounded bald area, out of which stick the ragged hair stumps (these can be readily disclosed by dabbing the area with a piece of wool soaked in chloroform, which, as this evaporates, shows the diseased hair stumps as white frosted excrescences).

(1) **Tinea tonsurans** appears as a series of rounded, bald areas on the scalp, varying in size from a sixpence to a penny, and later coalescing to form larger areas. The hair stumps can be detected as above and give the bald area a woolly appearance that easily distinguishes tinea from *Alopecia areata*, where the bald areas are not only irregular in shape, but quite smooth, and the skin usually shiny from trophic changes; this latter condition is neuropathic in origin and frequently follows the course of the cutaneous nerves on the scalp. This condition is frequently very intractable to treatment, especially if due to the small-spore fungus (90 per cent. of cases).

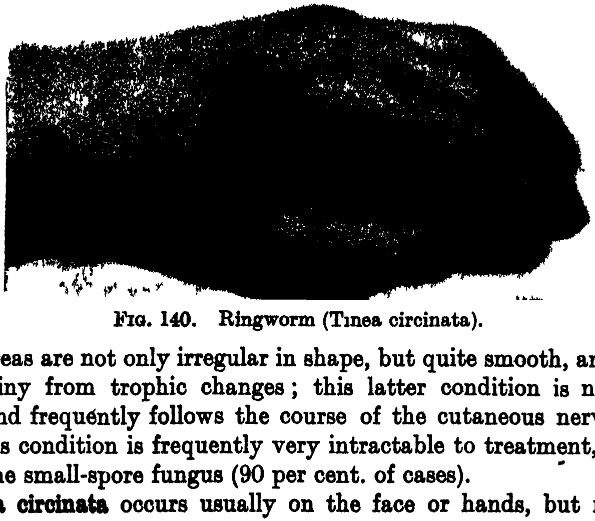


FIG. 140. Ringworm (Tinea circinata).

(2) **Tinea circinata** occurs usually on the face or hands, but may occur anywhere on the skin. The lesion is circular, slightly pigmented at the edge, and paler in the centre, where desquamation is occurring; if occurring in the beard or other hairy regions, the disease causes circular patches of baldness. The disease may also attack the nails (see p. 250), a position in which it is frequently unrecognised and which forms a potent source of reinfection after cure elsewhere.

Treatment consists in carefully-applied doses of X-rays, which must be just strong enough to depilate without destroying the hair follicles; or in applying strong antiseptic ointments, such as application of pure carbolic with a glass brush, or ung. chrysarobini, which it should be remembered severely stains linen.

Other diseases of a fungoid origin which require passing mention are:—

Tinea cruris, which occurs in the groins and axillæ and around the folds of the nates, and is common among young males in schools and barracks, where it forms a condition difficult to eradicate, being both very contagious and liable to recur; it is probably spread by bathing and by towels, etc., and the toe-nails are a frequent source of reinfection. Clinically itching is complained of, especially when hot; examination of the crutch reveals scaly patches of brown discoloration, and microscopy shows the hyphæ and spores.

Treatment consists in applying strong iodine or carbolic, or the application of an ointment containing salicylic acid.

Tinea versicolor, due to a small-spored fungus, is manifested by a scaly brown discoloration spreading slowly over the upper part of the chest, where it usually commences, and over the back, shoulders and, rarely, arms and neck.

Treatment is as for other forms of tinea.

Favus is a mycelial infection of the scalp, and occasionally other regions in dirty patients, and is rarely seen in this country. It is characterised by the formation of yellow cup-shaped crusts (scutula), which show up readily if the area is dabbed with chloroform. The disease is very intractable, and X-ray treatment, to be efficient, has usually to be applied in doses which will produce permanent baldness.

Sporotricosis, a disease due to a fungus, is rarely met with in England, but is common in France, America and Ceylon; there are apparently several varieties of sporotricosis. The mycelium can be found easily in cultures, but is seldom demonstrable in the lesions themselves, which consist of granulation tissue.

Clinically the lesions are usually in the skin and subcutaneous tissues of the hand and forearm, but may occur on the neck or legs, while rarely generalised metastases may be found in all the viscera. Infection may occur through an abrasion, but often no such lesion can be demonstrated in the primary focus. Whitish subcutaneous nodules, which later become brownish-purple and break down, forming ulcers, appear along the lymphatic vessels, and may vary in size from a cherry to a tangerine orange; partial healing, with formation of scar tissue, is often present.

Treatment consists in giving iodide of potassium by the mouth, and also using iodine as a local dressing. X-rays may hasten healing.

Diagnosis is easy if the fungus is found on culture: otherwise, apart from the purplish discoloration, tuberculosis or gummata may be diagnosed; while in advanced cases actinomycosis is closely simulated, though no granules occur in the discharge. Glanders may be suspected, but no lymphatic thickening is present, while blastomycosis often can be eliminated only by failure to find yeasts in the discharge.

(*d*) **Toxæmic manifestations** of many general infections occur in the form of skin lesions (rashes); thus the infectious fevers, poisoning due to drugs or toxæmias of unknown origin all have their characteristic rashes, by which they are indeed diagnosed; a description of these is not desirable in a surgical text-book, and for this the reader is referred to his manuals of medicine and dermatology. Suffice it to say that the rash is merely a sign of the general disease, and therefore calls only for symptomatic treatment *per se.*

In any case of *septicæmia* diffuse erythematous rashes often manifest themselves, and, indeed, purpuric rashes are not uncommon; such cutaneous lesions are of grave prognosis, and care must be taken that the case is not diagnosed as one of scarlet fever.

There are three conditions which merit special mention, as they are liable to confusion with surgical conditions.

Lupus erythematosus is a condition affecting the cheeks and bridge of the nose, where it gives rise to a chronic reddened inflammatory area of skin of a typical "butterfly" shape. Superficially the condition resembles an erysipelas or lupus vulgaris, but it can be distinguished readily by the fact that the sebaceous glands in the affected area are plugged with inspissated sebum, which is spread over the surface as branny desquamating scales, and the removal of one of these scales with its adherent plug on the under surface will at once make the diagnosis clear; the condition, about the ætiology of which little is known, though it may be a streptococcal infection, yields readily to ultra-violet light or X-rays in small doses, and is improved by dosage with sulphanilamide.

Erythema nodosum is a condition, possibly rheumatic or tuberculous in origin, in which multiple subcutaneous nodules appear under the skin of the shins, and the extensor surfaces of the forearms and feet. The nodules are painful and tender, may coalesce, and the skin over them is reddened and shiny. The condition is therefore apt to be mistaken for one of cellulitis, and indeed in some cases the differential diagnosis may be a cause of much difficulty, but the presence of normal skin among the erythema, the absence of lymphatic involvement, and the symmetry of the lesions on both shins usually will enable the correct diagnosis to be made.

Herpes zoster in its early stages presents painful erythematous nodules, on which vesicles only appear some hours later, and the condition, if seen in the early stages, may be mistaken for an erysipelatoid area: but usually other areas with vesicles are present, and there is severe pain radiating over the whole area of cutaneous supply of the involved nerve or nerve root.

GROWTHS OF THE SKIN

Tumours of the skin and subcutaneous tissues in most cases have been discussed in Chapter VIII., but it will be well briefly to enumerate those commonly met with.

The vast majority of the tumours in the skin are, of course, epithelial in origin, while those of the subcutaneous tissue are derived from connective tissue, but to whichever class they belong, the tumours may be either simple or malignant.

(A) *Epithelial Tumours. Simple epithelial tumours* are in the vast majority of cases papillomata, but an adenoma may rarely be met with.

Papillomata, popularly known as *warts* and *moles,* may be met with in any part of the skin, and may be sessile or pedunculated. In size they vary from a mere millet seed to a tumour covering half the body; such tumours are often pigmented, either from overgrowth of the melanin in the stratum granulosum or from ingraining of dirt among the villous-like processes of the neoplasm.

Clinically one or more villous tumours or nodular excrescences are present, the skin of which is thickened and discoloured, that around being normal; there is no enlargement of neighbouring lymph nodes unless the whole tumour be septic, a not uncommon complication, in which case the nodes will be enlarged and tender.

Treatment consists in excision together with the area of skin in which the neoplasm arises, and suture; this is urgently indicated if in the case of a pigmented mole enlargement is taking place, as such tumours are likely to become malignant, *i.e.,* melanotic sarcomata or carcinomata. Very large tumours are unsuitable for excision owing to their size, but may be treated by the application of radium in plaques or CO_2 snow to the edges. Multiple small warts yield readily to treatment by CO_2 snow, X-rays, radium or ionisation with zinc or iodine, and these methods are preferable to excision in cases where large areas are covered by minute papillomata.

Venereal warts and **condylomata** around the genitalia are probably the result of infection and irritation, and disappear if the parts are kept clean and dusted with iodoform or zinc and starch powder, and the venereal disease suitably treated.

Adenoma sebaceum is a rare tumour arising in connection with sebaceous glands, usually met with on the scalp as a small reddish mass fixed to the skin and often ulcerating.

Treatment consists in excision.

Rhinophyma is a condition met with in the skin covering the nose, usually in elderly men, when an overgrowth and blockage of sebaceous glands leads to a development of numerous cysts, and an inflammatory subcutaneous formation of fibrous tissue between these, with consequent œdema and thickening of the overlying skin. The whole area presents a lobulated appearance, the skin being cyanotic and thickened and the gland mouths gaping and prominent.

Fig. 141. Gonorrhœal warts of the vulva.

Treatment consists in paring away the excrescences till the nose assumes a normal outline; epithelialisation occurs readily from the deeper parts of the embedded sebaceous glands.

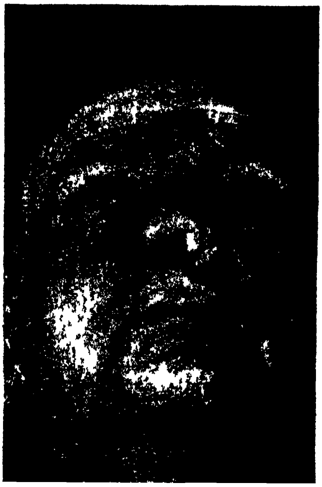


Fig. 142. Rhinophyma.

Fig. 143. Rhinophyma.

Molluscum contagiosum is an affection of unknown origin, but undoubtedly infectious, which manifests itself as a series of semi-translucent umbilicated raised nodules, which usually appear on the skin of the face or neck, but may be met with on the hands or elsewhere. The nodules consist of columns of nucleated polygonal cells, and in the centre these are degenerate and hyaline in appearance; hence the umbilication. These hyaline "molluscoid bodies" can be expressed from the nodules.

Treatment consists in excision, or incision and curettage, with removal of the fibrous capsule surrounding each nodule.

FIG. 144. Molluscum contagiosum.

Hutchinson's Potato Tumour. An endotheliomatous mass developing in connection with the carotid body is occasionally seen, and calls for excision (Chapter X., Vol. II.). Tumours in connection with the branchial clefts may also be met with along the anterior border of the sternomastoid in the skin or subcutaneous tissues of the neck (see Chapter X., Vol. II.).

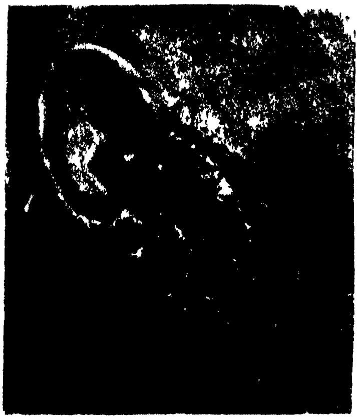


FIG. 145. Epitheliomatous ulcer (squamous-celled carcinoma).

Malignant epithelial tumours take the form of squamous-celled carcinomata or one of its two specialised forms met with in the skin, rodent ulcer and melanotic cancer. Very rarely a columnar-celled carcinoma may arise in connection with the epithelium of a sebaceous gland, but is so uncommon as not to merit description.

Squamous-celled carcinoma (Chapter VIII., p. 190) may occur in any situation, but is particularly likely to occur in old-standing scars, especially of lupus and burns, at the mouths of sinuses, in chronic ulcers, and in neglected and suppurating sebaceous cysts. The neoplasm first appears as an indurated raised area, which may be definitely papillomatous and spreads both superficially and deeply into the tissues. Ulceration soon occurs, the ulcer presenting the typical hard rolled-over raised edge, and its floor being composed of broken-down epitheliomatous tissue. The nearest lymph nodes become affected, being fixed in the tissues, hard and matted together, but not much enlarged in the early stages.

Treatment consists in excision of the lesion, with a margin of at least ½ inch of healthy surrounding tissues, the subcutaneous tissue and lymphatics, and the nearest lymph nodes in one mass, with suture where possible and skin grafting otherwise. Radium is very useful in these cases.

Carcinoma may spread into the skin from deep growths, as in the breast, either by direct continuity or by permeation *via* lymphatics, and in these cases treatment is such as is indicated for the primary lesion.

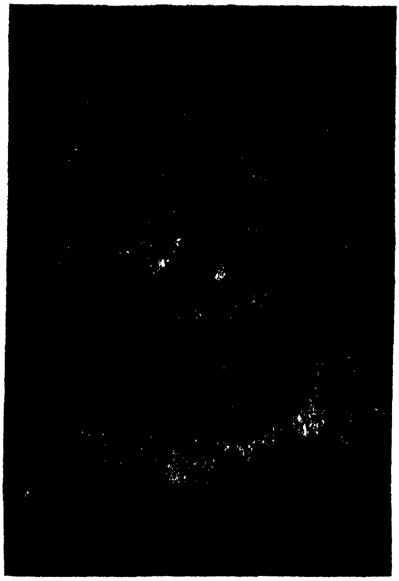


FIG. 146. Rodent ulcer (superficial type).

Rodent ulcer arises in the deeper layers of the dermis, possibly in the sweat or sebaceous glands, while some authorities regard it as a "basal-celled carcinoma" of the skin, and is most commonly met with on the face above a line joining the lobule of the ear to the angle of the mouth. Here it is by far the most frequent ulcer met with, but it may occur occasionally in other situations, such as the neck, forearm, etc. Most often the neoplasm originates at the inner or outer canthus of the eyelids, more frequently on the lower lid, or on the side of the nose; it is uncommon in people under forty years of age and, as stated on p. 188, cell nests are rarely met with if sections of this neoplasm are examined microscopically. The disease is commoner in the hot and dusty countries of South-East Europe, Asia and South Africa than in North and Central Europe or North America. The rodent ulcer commences as a flattened indurated nodule, which increases very slowly in size, and later exudes a serous fluid which dries on the surface, forming a scab, which is frequently "picked off" by the patient, who dates the growth of the ulcer from that date. Ulceration takes about a year to set in and then the edge shows the typical rolled-over, hard and heaped-up appearance met with in malignant ulceration; the base is dry, red and glazed. It, however, spreads but slowly, and shows a marked tendency to heal and scar over in the centre, or even at places around the periphery. At the same time, however, most rodent ulcers tend to eat deeply into the tissues beneath, which in course of years are totally destroyed, the most revolting disfigurement being produced by destruction of the eye, bones of nose, orbit, etc.; the brain and dura mater may be exposed. Dermatologists usually recognise three types of rodent ulcer: (*a*) a superficial type, which spreads only on the surface, does not penetrate, and may be mistaken readily for lupus, from which it often can be distinguished only by microscopic section; (*b*) a mixed type, that ordinarily met with, which spreads very slowly both superficially and deeply, and, moreover, tends to scar, and if left untreated takes years

FIG. 147. Penetrating rodent ulcer.

to produce a fatal result, though it may produce deformity both by scarring and destruction of tissue; and (c) a penetrating type, which rapidly destroys tissues, and indeed closely resembles a squamous carcinoma, though, as in the other types, involvement of the lymph nodes is very rare. The longer the condition goes on, the more malignant it tends to become. Rodent ulcer, indeed, is the one type of malignant tumour in which metastases never occur; hence the lymph nodes in the neighbourhood are not affected unless the ulcer is septic, a common complication in neglected cases, when they will of course be enlarged and tender, and may even suppurate

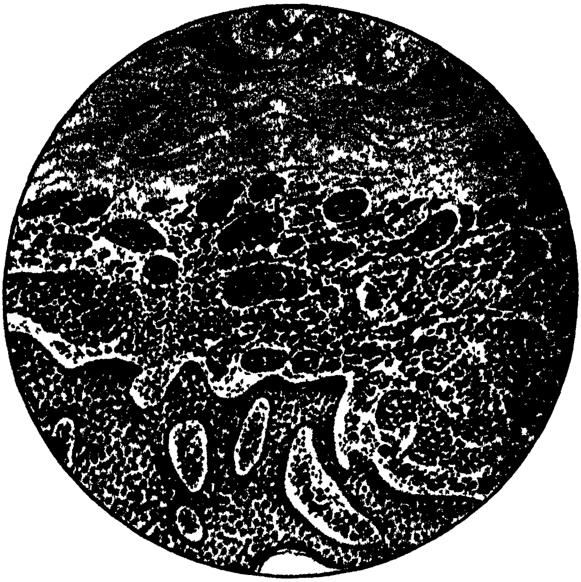


FIG. 148. Melanotic carcinoma (× 45).

The ideal *treatment* consists in complete excision, and this should be carried out early to be successful, skin grafting being frequently necessary to fill the resultant gap in the skin. Ulcers of the mixed and penetrating varieties must be treated by excision, as light or radium treatment tends to convert the mixed into the penetrating type, and both into squamous-celled carcinoma. The typical rodent ulcer shows very marked differences in its malignancy, and these ulcers differ much in their response to radium. They may be, from a radiological standpoint, divided into three types: (a) Those which respond at once to plaque treatment of one hour and heal completely; they are usually the type which are hypertrophic and raised above the skin; (b) a second type which under treatment becomes stationary but never quite heals; and (c) a third type, the deeply ulcerative, which advances despite all treatment. Once bone becomes involved, the chances of permanent healing are small. Treatment by X-rays, ultra-violet rays, radium, ionisation, and CO_2 snow should be limited therefore to ulcers of the superficial type, and even here must take second place to excision and skin grafting or suture, which gives a more rapid result

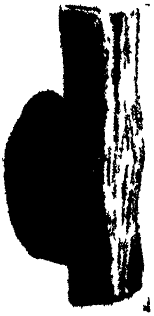


FIG. 149. Melanoma in skin.

and is less likely to be followed by relapse. In those cases where excision is impracticable, either from the size or situation of the ulcer, X-rays or radium may be tried, but are liable to aggravate the growth of the tumour rather than alleviate the condition; the same applies to such treatments as curetting or cauterisation, and probably the best thing to do in advanced cases is—nothing, except keep the ulcer clean and protected.

Melanotic Cancer (Chapter VIII., p. 191). Under this heading are included all tumours containing excessive melanin; some of these are apparently simple, but are very prone to become malignant, while others are either of a sarcomatous or more usually carcinomatous nature.

Such tumours are black or dark brown in colour, and may occur anywhere in the skin; the primary growth may be so minute as to escape notice, or may enlarge and fungate through the epidermis. Dissemination is very rapid, and multiple, pigmented nodules occur along the lines of the subcutaneous lymphatics; the lymph nodes are early and extensively affected, and soon break down and ulcerate. At the same time blood-stream dissemination causes metastases to appear in the lungs and other internal viscera. Melanin may be detected in the urine, and death is rapid in these cases. In one type commonly met with on the sole of the foot or around the matrix of the nails, although glandular metastases are early, blood dissemination is late, and this type of neoplasm, which appears to be a carcinoma starting in the deeper layers of the skin, may be eradicated with the knife, together with the lymph nodes and subcutaneous lymphatics in one mass, with a fair prospect of effecting a cure. But where dissemination to internal organs has occurred surgical interference is of course useless.

(B) *Connective tissue tumours* may arise in connection with the nerves and blood vessels in the skin, and are common in the subcutaneous tissues. Of the simple neoplasms, those most commonly met with in the skin are *fibromata and neurofibromata* (Von Recklinghausen's disease), and *capillary hæmangiomata;* the former tumours giving rise to firm and frequently pedunculated nodules of varying size and consistency, and the latter to a purple tumour, the colour of which disappears on pressure, varying from the thread-like "spider nævus" to the disfiguring "port-wine stain," which may cover half the body.

In the subcutaneous tissue *lipoma, nævo-lipoma, soft fibroma, cavernous hæmangioma and lymphangioma* are all commonly met with, lipoma being the most common and presenting a soft, semi-fluctuant lobulated mass, slightly adherent to the skin and having a definite rounded edge. The characteristics of all these tumours have been fully discussed in Chapter VIII.

Treatment consists in excision, except in the case of capillary nævi, which may be treated with CO_2 snow or radium, and certain very large cavernous nævi, where electrolysis or injection is advisable (see Chapter VIII.).

Malignant connective tissue tumours (sarcomata) are met with not infrequently in the subcutaneous tissues as a primary growth, and are usually of the spindle-celled variety and associated with more or less fibrous tissue. They present a fixed mass, involving early both skin and deep fascia, with no definite edge, and the more fibrous tissue they contain the harder they are.

Treatment consists in free excision or radium can be inserted in and around the tumour, but recurrence even in the fibrous types is common (recurrent fibroid of Paget p. 196) and the prognosis is poor.

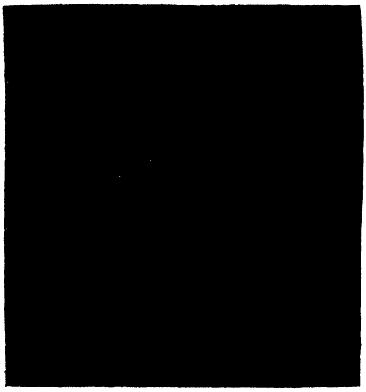


FIG. 151 Epithelioma in an ulcerated sebaceous cyst

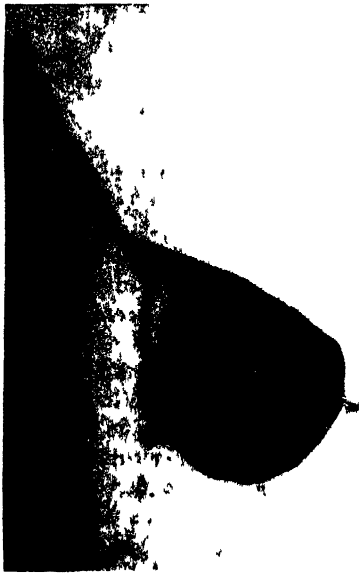


FIG. 150. Sebaceous horn growing from the scalp.

FIG. 152 Orbital dermoid cyst.

FIG. 153. Sebaceous horn on the ear.

CYSTS OF THE SKIN AND NEIGHBOURING TISSUES

Cysts occurring in the subcutaneous tissue have been fully discussed on pp. 220—224, and are here only briefly mentioned.

Sebaceous cysts are commonly met with on the scalp and face, and are attached to the skin, the blocked opening of the sebaceous gland being frequently seen on the surface as a black speck. If neglected they may reach a large size, and are frequently multiple. *Suppuration* may occur, after which the gland may break and discharge; the resulting inspissated mass may gradually increase and accumulate until it forms a **sebaceous horn,** or malignant changes may occur and a *carcinoma* result.

Treatment consists in excision in the early stages, care being taken to remove the cyst wall completely.

Dermoid cysts, either "sequestration" or "tubular" in type, are generally met with in the mid-line or around the angles of the orbit; they are usually present from birth and grow slowly, not being attached to the skin, but frequently to deeper structures. *Branchial cysts* may be met with in the neck along the anterior border of the sternomastoid muscle, and treatment in all cases consists in removal.

Implantation dermoids (so-called) result from the pushing-in of portions of skin by a blunt instrument; this skin subsequently curls round, unites at the edges, and makes a small cyst, which is usually met with on the palm of the hand or ventral aspect of the digits, lying just under the skin, on which careful search will reveal a scar. The cyst should be excised.

Parasitic cysts also occur, and have been discussed on p. 237 and Chapter VI., p. 137.

VASCULAR AFFECTIONS OF THE SKIN

Chilblain (Chapter IV., p. 64) (Erythema pernio) usually occurs on the skin of the fingers, toes or ears of persons with a "poor circulation" as the result of exposure to damp cold. The skin is first blanched and cold, and then, as the circulation returns, becomes purplish, œdematous and shiny; at the same time an itching and smarting is experienced in the area. In severe cases thrombosis with formation of a black slough may occur, or the skin may ulcerate and infection result following the formation of a "blood blister." The condition, which is analogous to frost-bite (Chapter IV., p. 63), is also undoubtedly aggravated in those persons suffering from disturbances of the neurovascular mechanism, and thus is frequently associated with the milder forms of *Raynaud's disease* (Chapter VII., p. 159).

Treatment consists in producing hyperæmia by Bier's congestion or ultra-violet or X-rays and applying mild counter-irritants to the area, such as tinct. iodi or Friar's balsam. Rarely amputation may be necessary, and before it is resorted to, excision of the semilunar ganglion or sympathectomy should be tried.

Erythema ab igne is a reticulate pigmentation, not disappearing on pressure, occurring on the fronts of the shins of people exposed for long periods to heat from fires and furnaces. It calls for no special treatment, and is analogous to the pigmentation seen in the scars of varicose ulcers.

Gangrene (Chapter VII.) of the skin and subcutaneous tissues may follow trauma, or be the result of a failing circulation, arteriosclerosis or infection; it may be moist or dry. The part is discoloured, insensitive and cold to the touch, and, being dead, needs removal.

Trophic ulcers occur in injuries and diseases of the peripheral nerves, especially if the nerve lesion is incomplete; also in diseases of the lower motor neurone, *e.g.*, myelitis, infantile paralysis; they result from slight trauma to the insensitive and poorly nourished tissues. The resulting ulcer is usually superficial, ragged and infected, the granulations scanty and pallid, and healing slow or absent, the skin in the surrounding area being bluish and shiny. In some cases, however, especially in the sole of the foot, a **perforating ulcer** results, which spreads deeply, involving the tarsal joints and leading to necrosis of the adjacent bones. Such perforating ulcers are common under the ball of the great toe in tabetic subjects, and often lead to the destruction of the first metatarsophalangeal joint and neighbouring bones; in appearance the ulcer is characteristic, presenting a deep sinus leading into the joint, lined with but little granulation tissue and with a very slight discharge; there is no pain, and the epithelium around the edges is heaped up, white and desquamating; more than one ulcer may be present.

Perforating ulcer occurs not only in *tabes,* but more rarely is due to—

(*a*) Spinal lesions, such as syringomyelia, spina bifida, and myelitis (where it occurs over pressure points, such as the sacrum and heels, and is seen as a "bed sore" (Chapter III., Vol. II.)).

(*b*) Peripheral nerve lesions: (1) neuritis from alcohol, lead, arsenic and diabetes; (2) injuries to nerves (Chapter XII.).

(*c*) Infection and trauma (*e.g.*, cutting a corn) in old people with arteriosclerosis.

The *treatment* is not usually very successful; the area should be kept clean and free from pressure, the hypertrophied skin pared away, and the sinus gently curetted, but amputation is often necessary owing to involvement and destruction of bones and joints.

AFFECTIONS OF THE NAILS, PARONYCHIA

The nails are from their situation liable to damage and infection, and it is customary to devote a special paragraph to the commoner diseases affecting them. The nails may be injured or grow roughened from disease, but usually recover; as it takes from six weeks to two months to grow a new nail, they should have returned to their normal state in that time, provided the source

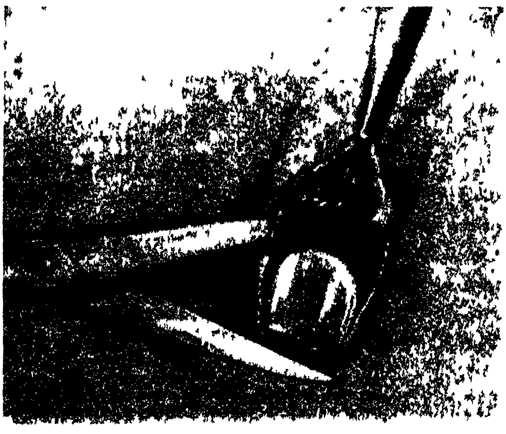


FIG. 154. Showing the skin reflected and the scissors being passed under the nail bed. (See also Fig. 132, p. 229.)

of the deformity has been dealt with and that no permanent damage has been inflicted on the "nail bed."

Two varieties of whitlow are met with affecting the nails.

(1) The **subcuticular type** occurs in the fold around the nail (**paronychia**), usually as the result of injudicious cleansing of the folds with a dirty nail-brush. The skin becomes red, swollen and tender, and pain gradually develops as pus forms under the cuticle; if not quickly let out by incision it tends to work under the nail, which it separates from the nail bed. Granulations then form around the nail and beneath it, and in course of time it is cast off, and the infection settles down, but the resulting nail is likely to be deformed; it is therefore advisable to remove the nail at once as soon as the pus is detected beneath it, as this both shortens the period of infection and lessens the chances of the new nail being deformed.

(2) **Subcutaneous whitlow (Onychia suppurativa)** is seen in severe and neglected cases of paronychia, and follows the introduction of infected foreign bodies, such as splinters, beneath the nail. A chronic form of the disease occurs in children, due to tuberculous and syphilitic infection of the nail bed, which becomes replaced by a mass of granulations, the whole terminal phalanx being swollen and discoloured.

Treatment in acute cases consists in evacuation of the pus through an incision *lateral* to the nail bed running from the nail fold. In extensive infection two such incisions need to be made; the skin between them is raised and the nail exposed and cut away from its bed as far as it is undermined by pus or granulation tissue. Prompt treatment thus enables the exposed nail to be left as a protection, which is not possible in neglected cases where the pus has spread under it. Unless care is taken to incise laterally to the nail, this may be cut into and a permanent longitudinal fissure then results, a very annoying disability. In chronic and tuberculous cases, Bier's hyperæmia is very valuable, and ultra-violet and X-ray therapy often cure; syphilitic cases yield to general treatment.

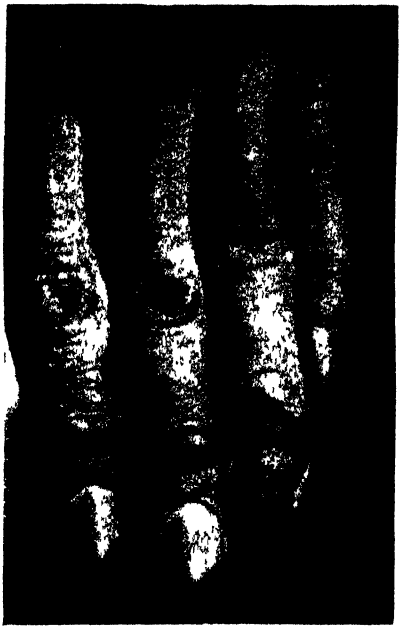


FIG. 155. Chronic paronychia of tuberculous origin.

Ingrowing toe-nail is met with usually in the great toe, and results from neglect in cutting the nails, a sharp edge being left sticking into the skin fold, which ulcerates following pressure from the boots, becomes infected, and granulations spread over the nail, which thus appears to "grow in." The condition is thus homologous with a paronychia, and the treatment consists, in the early stages, in removal of the rough nail edge and granulations and subsequent proper paring of the nails. In the later stages many ingenious operations for removal of strips of nail or plastic procedures on the skin have been devised and practised, but removal of the nail, with curetting away of the granulations, offers the only chance of successful cure, though owing to the damage already done to the nail bed, the resulting nail is apt to be deformed and cause further trouble.

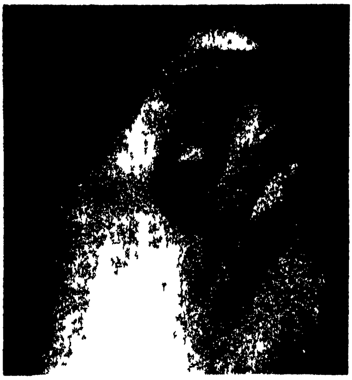


FIG. 156. Hallux valgus with hammer toe and onychogryphosis.

Subungual exostosis (Chapter VIII., p. 204) is a condition which causes deformity of the nail of the great toe.

Onychogryphosis is a condition of thickening, twisting and overgrowth of the nails, due to chronic infection and irritation, and is usually met with in the toe nails of elderly people of uncleanly habits of many years' standing.

Treatment consists in removal, but the new nail is nearly always deformed.

Ringworm (Tinea) is very likely to attack the nails, which are thickened, rough and brittle, and easily break away. *Treatment* consists in ionisation with iodine and the use of antiseptic ointments, but the condition is most difficult to cure.

ELEPHANTIASIS AND ŒDEMA

As the result of the fibrosis consequent upon long-standing inflammatory reaction in and around the blood and lymph vessels, or from tumours pressing on or growing within these structures, such vessels may become partly or entirely obliterated, with a consequent damming back of blood and lymph distal to the obstruction. In such a case the affected part becomes full of fluid and swollen, a condition known as *œdema*, which may be mainly venous or lymphatic in origin, according as the obstruction chiefly affects blood or lymph vessels.

There is a type of chronic swelling of one leg, often accompanied by some œdema, which is met with in young and rather obese women and girls from fifteen to twenty years of age. The œdema is apparently partly venous and partly lymphatic in type, and arteriography shows that the arteries of the limb are unduly small in size.

The condition is very intractable, and though it can be improved temporarily by massage or Kondoléon's operation, the effects are only temporary; lumbar sympathectomy has been tried in these cases with some success, but it is as yet too early to say whether permanently beneficial results will be obtained.

Venous Œdema is characterised by a dusky discoloration of the skin of the part distal to the site of obstruction. The whole area is much swollen and the skin stretched and shiny; free fluid is present in the tissues, which feel soft and boggy and pit on pressure, and in severe cases it may ooze out from the skin glands. When œdema is very marked and generalised, as in cases of failing compensation in cardiac disease, there may be fluid effused into the serous cavities (*ascites*) and generalised œdema of the body (*anasarca*).

Lymphatic Œdema, on the other hand, presents a skin paler than normal and tending to be thickened and coarse, the gland mouths showing as pits (*peau d'orange* or pigskin). The whole area is swollen, but hard and firm, and little or no pitting occurs if pressure is applied with the fingers. In chronic cases the thickening of the skin and subcutaneous tissues may be enormous, and is due to actual over-growth resulting from the increased supply of lymph; this is further aggravated by infection from the dirt which accumulates in the folds and gland mouths of the roughened skin; the condition may then assume the form of hideous deformity, and is known as *elephantiasis*.

Lymphatic œdema is most commonly met with in:—

1. *The upper extremity* as the result of involvement and blocking of the axillary lymphatics in advanced carcinoma of the breast, or when recurrence occurs after its removal. The affected arm usually feels painful and tight, and in the early stages looks normal except for some œdema, which persists on the inner side of the arm above and behind the internal condyle of the humerus. Later the whole limb becomes swollen, white, painful and useless, amputation being the only effectual remedy.

2. *The lower extremity*, as the result of long-standing and neglected gummatous or other infection of the lymph nodes and subcutaneous tissues of the thigh; a condition usually met with in elderly women, who show an enlarged and rather painful lower extremity, much swollen but normal in colour, and usually freely scarred by numerous old papery scars of gummatous ulcers, which may be present in an active condition.

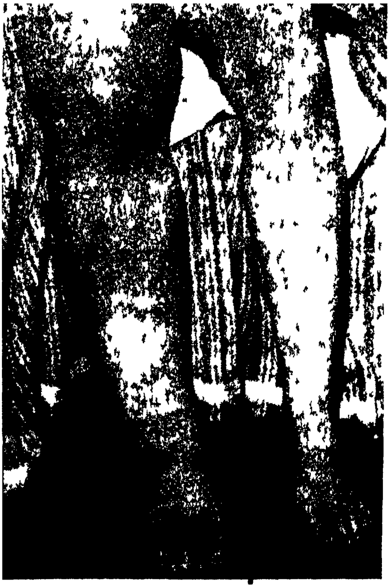


FIG 157 Lymphatic œdema of the right lower limb.

Phlegmasia alba dolens (white leg) is a condition met with in younger women, usually following sepsis and pelvic cellulitis after parturition; it is often seen in elderly patients after abdominal operations; the leg is shiny, white and swollen, painful, and pits slightly on pressure, due to a mixed œdema from blockage of veins and lymphatics from the infection and thrombosis in the pelvic cellular tissue. It is almost always in the left leg.

The œdema met with below chronic varicose ulcers is similarly of a mixed nature.

Toxic œdema of the shins, where the skin is shiny and white and the tissues pit on pressure, occurs in renal disease, severe anæmias, and the late stages of cancerous cachexia; it is usually seen over the shins, but in the case of renal disease affects the eyelids and joints. Bilateral œdema of the forearms and hands is commonly seen in laundry workers following immersion of these parts for some hours in hot washing soda solution.

Angio-neurotic œdema is a condition in which severe transitory œdema, probably of neuropathic origin, occurs suddenly in various situations, usually lasts an hour or so, and as suddenly disappears. It is only serious if it occurs in the region of the glottis, when it causes urgent dyspnœa and may call for immediate tracheotomy to save life.

Œdema of the glottis may follow cellulitis of the neck, or submaxillary region (Ludwig's angina), and is fully dealt with in Chapter IX., Vol. II.

Œdema, it must be remembered, occurs in all acute inflammations, when it is accompanied by redness, pain and tenderness, and a raised temperature.

The *treatment* of the various forms of œdema depends on the cause, for it must be recollected that the œdema is only a sign of back pressure. The first thing to be done is to determine the site and cause of this blockage of the vessels, and then discover whether it affects veins, lymphatics, or both.

In the early stages, rest to the affected area with support of the congested part by elastic or crêpe bandages, applied from the periphery towards the centre, and suitable treatment of the infective agent is usually all that is indicated, and in the course of six weeks to three months new channels will form, which will enable the circulation to be re-established; but even so some permanent thickening is likely to persist in the part. In cases of venous œdema due to general cardiac disease, or toxic œdema from renal disease, etc., the primary condition needs treatment, but in those cases where large effusions exist in the serous cavities, " tapping " with a trocar and cannula may be necessary for the relief of pressure on vital organs, and must be carried out, when necessary, under careful aseptic precautions.

In old-standing cases of lymphatic œdema attempts may be made to form new lymph channels by the introduction of silken strands, chains, etc., into the subcutaneous tissues at the junction of the normal and affected areas (*lymphangioplasty*), but the results are neither lasting nor encouraging, and in severe cases amputation affords the only sure means of relief.

Elephantiasis, as already pointed out, results from a mixture of chronic lymphœdema with superadded infection and fibrosis. The condition is usually met with in the lower extremities and external genitalia, and is not common in this country.

Elephantiasis Arabum is the result of the growth in and blockage of the lymph vessels in the groin and pelvis by a parasitic worm, the *Filaria sanguinis hominis*, which is met with in the West Indies, South America, and the Pacific Islands, the infection taking place in the first instance from drinking water in which the bodies of dead mosquitoes (the intermediate host) have fallen. The ova are ingested through the gastric mucosa, and enter the portal venules, where they hatch out and the adult worms lodge; many embryos are produced, and these block the lymphatics or enter the blood stream, whence they get removed by mosquitoes. The condition is so seldom seen in this country as to merit little notice, but the deformity and disability produced by the huge thickening of the skin and subcutaneous tissues are very great, the penis being buried in a mass of œdematous tissues and the scrotum being as big as a football or larger.

Treatment is very unsatisfactory, and consists in stripping off the skin and subcutaneous tissues from the underlying parts and skin grafting, excising wedges of tissue, or in lymphangioplasty; none of these methods give good results, but the first is the most successful.

Other forms of elephantiasis due to lymphatic and venous obstruction are met with more often in this country, and the commonest cause is a *diffuse gummatosis* in long-standing cases of syphilis (see Chapter XI., pp. 311, 313). Other causes are *carcinomatous infiltration*, *chronic sepsis*, as occurs in the legs of women with chronic ulcers, and occasionally *widespread tuberculosis* or *lupus*; in all of these cases lymphangioplasty may be tried, but amputation has frequently to be resorted to. *Macroglossia and macrocheilia* (Chapters IV., V., Vol. II.) may be due to gummatous or lupoid lymphœdema, or to neurofibromatosis. A similar condition may occur in the scrotal tissues in cases of chronic eczema with infection in infants and old men.

Elephantiasis may also occur due to causes other than lymphatic obstruction, the two common types being :—

Elephantiasis nervorum. Neurofibromatous elephantiasis of Virchow (see Chapter XII., p. 342).

Elephantiasis Græcorum, a condition closely allied to the preceding and occurring in the face and forearms of patients with advanced nodular leprosy (Chapter XI., p. 313).

CHAPTER X

THE BLOOD VESSELS

Surgical Anatomy. The blood vessels consist of the three main varieties,—arteries, capillaries and veins. In the skull a special enlarged form of vein occurs, which is known as a venous sinus, while similar venous sinuses are occasionally found in other parts of the body in connection with tumour formations. Considerable difference exists in the structure of the arteries, the veins and the capillaries. An artery has three coats; the internal coat is known as the tunica intima and consists of a single layer of flattened endothelial cells, which form the lining of the vessel, and which are surrounded on the outer side by some thin connective tissue and a moderately dense layer of longitudinally arranged elastic fibres. The middle coat is known as the tunica media, and consists chiefly of unstriped muscle with its fibres arranged circularly around the vessel. There are also some longitudinal muscle fibres and a certain amount of elastic tissue. This layer forms the greater part of the vessel wall. The outer coat, or the tunica externa, is composed of fibrous tissue, with a certain amount of yellow elastic tissue as well. Thus it will be seen that the tunica intima is thin and easily torn, and the tunica media thick and capable of contracting or expanding. The walls of the arteries themselves are well supplied with blood by means of the vasa vasorum, which run in the outer coat. There is also an extensive sympathetic nervous supply and a system of lymphatic channels, which drain the vessel walls. Outside the artery itself lies a connective tissue sheath, which is not very closely attached to the vessel wall, so that the artery is often capable of retracting within its sheath. The larger the artery is as a rule the stronger and more definite its sheath is, while the smaller arteries have a much larger proportion of muscle and elastic tissue in their wall, relative to their size, than do the larger ones.

The **capillaries** are of very much simpler construction. They contain no muscle fibres or elastic tissue and their wall consists of a single layer of flattened endothelial cells.

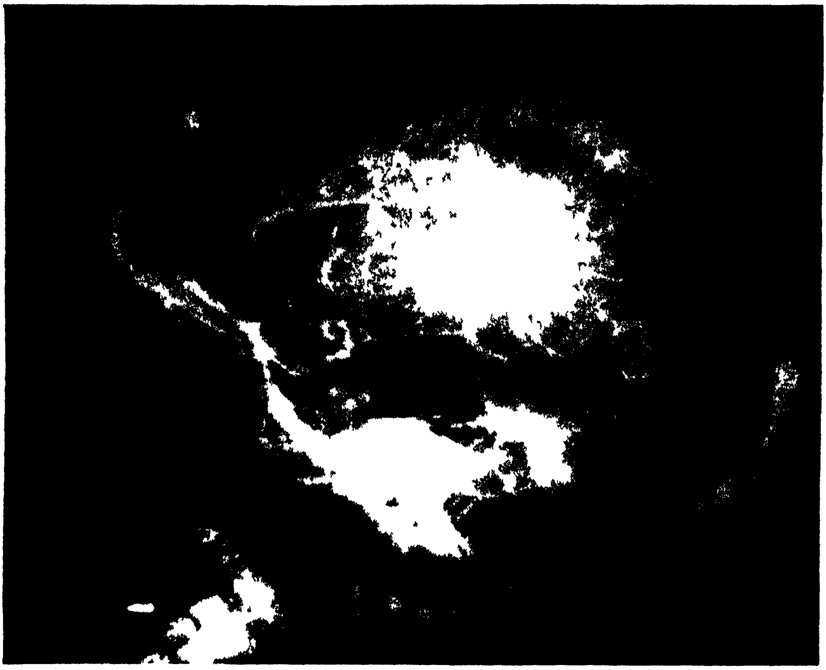
In the case of the **veins** the wall is again constructed in rather a different way, being much thinner and containing very little muscular tissue. The inner layer is stronger than that of an artery, while the middle and outer layers are more or less fused together and consist of fibrous tissue with a small admixture of elastic fibres. Most of the veins in the body are provided with valves at intervals, which prevent the blood flowing in the wrong direction, and these valves consist of semilunar folds, constructed of fibrous connective tissue, covered with the ordinary endothelium. In most cases such a valve consists of a single semilunar flap, though in some cases two of these flaps are present, and they are thus somewhat similar to the aortic and pulmonary valves of the heart. Certain important veins are found to be without valves. There are none in the portal system, while the superior and inferior venæ cavæ, the hepatic, renal, spermatic, rectal, iliac, common femoral and jugular veins are usually without them. In many cases when a vein becomes over-distended the valves do not function properly, and this may, in turn, lead to the vein becoming even more distended, so that a vicious circle is established.

It will thus be seen that when an artery is cut the elastic and muscular tissue in its wall gives it the power of contracting and retracting in a way which cannot occur when a vein is injured, so there is much less tendency for the spontaneous cessation of hæmorrhage in the latter case.

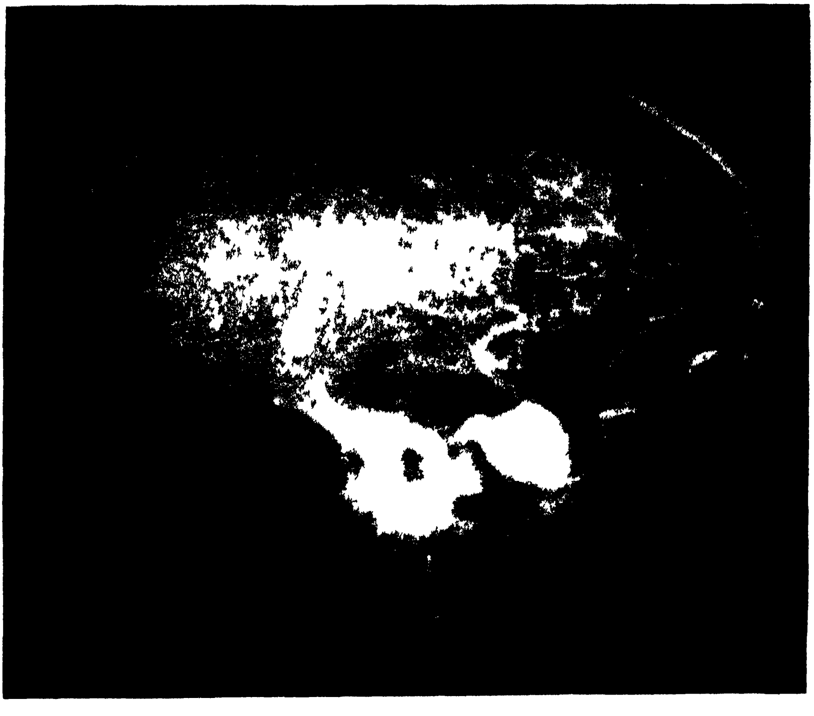
In connection with diseases of the blood vessels pulsation is a very important clinical sign, and great care must be taken to distinguish between a swelling which has true *expansile pulsation*, which causes it to increase in size as well as move forward at every pulse, and one which exhibits *transmitted pulsation* from a vessel behind and merely moves forward without increasing in size at each beat.

Collateral Circulation. When from any cause the flow of blood in a large artery is blocked, the vitality of the distal parts supplied by that vessel can only be preserved by the dilatation of neighbouring vessels and branches of vessels, and

PLATE I.



A Arteriogram showing the normal condition of the cerebral vessels



B Arteriogram showing an arterio venous aneurysm between the internal carotid artery and the cavernous sinus

To face p 255.

this process is known as the formation of a collateral circulation (see pp. 302–311). These anastomoses between branches of the main vessel above the block and branches below the block are opened up and enlarged, so that the blood can be conveyed back into the main vessel below the obstruction. This is produced by an active vasodilation followed by an actual increase in the size of the vessels and helped by a rise in the general blood pressure. It may be hindered by disease of the vessel walls, severe injury to the vessels, pressure upon the vessels by an aneurysm or hæmatoma, venous stasis, and certain anatomical peculiarities in some regions. The process of establishing a collateral circulation is a gradual one and takes some hours or days : thus not only will it prove much more efficient when the arterial obstruction has come on gradually, but the dangers of gangrene following an obstruction to a main vessel are very much less if the complete occlusion of the vessel has been preceded by a gradually increasing partial obliteration.

Since by means of the vascular system the blood is pumped about the body within hollow tubes to nourish the tissues and organs, it is clear that important general effects will be produced upon the body either (1) by leakage of blood from these tubes (*i.e.*, hæmorrhage), and (2) by substances other than normal blood obtaining entry to these tubes—such as bacteria, particles of solid material, toxic chemical bodies, etc.

Arteriography. Recently, by the injection of opaque solutions—such as thorotrast (thorium oxide)—into the arteries, it has been possible, to take X-ray photographs by which abnormalities of the vessels or lumina can be detected. Probably the clearest pictures are obtained with thorotrast, 8–10 c.c. of which are injected into the artery above the site of the suspected lesion, and an immediate X-ray picture taken.

The injection is not without risk to the patient, however, and should be used sparingly and with great discrimination, for thorotrast is a radio-active substance which is taken up by the endothelial tissue and is ultimately absorbed by the cells of the liver, where it exerts a deleterious effect ; if large doses have been used it may prove fatal.

Hæmorrhage. A full description of the various forms of hæmorrhage with their predisposing causes, real causes and treatment will be found in Chapter IV. Some special terms applied to hæmorrhage which are self-explanatory are as follows : arterial, venous, capillary, external and internal; while localised collections of blood are known as hæmatomata or extravasations, according to their situation and shape. Blood in the urine is known as hæmaturia, in the stools as melæna, in a vomit as hæmatemesis, and in the sputum as hæmoptysis.

INJURIES OF ARTERIES

The importance of an injury to an artery will depend naturally very largely upon the size of the vessel injured, while the vessel wall may be injured in an open wound or damaged subcutaneously.

Contusions. An artery will be bruised by a blow or crush applied directly to it, and as a rule, if the vessel wall is healthy, the consequences are very insignificant, owing to its natural elasticity and vitality. If, however, the vessel wall is diseased, being atheromatous or calcified, quite a small bruise may result in the formation of a thrombus, which will block the vessel temporarily or permanently, and gangrene, usually of the dry type, may set in in the limb beyond. Bruising of the walls of an artery is most likely to occur in the case of those vessels which run near to or upon a bone.

In other cases the bruising of the vessel wall, especially if it is unhealthy, will weaken it, so that in the course of a few weeks or months it will yield before the blood pressure and give rise to an aneurysm at the injured spot.

Occasionally an artery will be bruised at the bottom of an open wound; this is not likely to be serious unless sepsis supervenes, for if this occurs ulceration with secondary hæmorrhage may follow.

Subcutaneous Rupture. A rupture of an artery may be due to a direct blow or strain, or occasionally to a displaced fragment of bone in a fracture or dislocation. In other instances the damage has been caused by the manipulations necessary to reduce a dislocation or to break down adhesions, and this is most commonly seen in old-standing dislocations of the shoulder joint; it is not likely to occur unless the vessel wall is diseased.

(*a*) **Incomplete Rupture.** This is the more common form, and in it the two inner coats give way, while the tunica externa remains intact. The middle coat will retract, but the intima is so elastic that it curls up inside the vessel and forms a valve, which will interfere with the passage of blood, so that in most cases a thrombus is formed and the vessel becomes occluded. In other instances, especially where the injury affects only one side of the vessel, complete thrombosis will not occur, but an organising clot will form over the damaged segment, so that the lumen becomes narrowed and the injured wall may remain weakened and gradually become distended to form a *traumatic aneurysm.* Occasionally a dissecting aneurysm (see p. 269) will be the result of this type of injury.

The site of the injury will be tender and slightly swollen, while pulsation of the vessel beyond the injured spot will be arrested temporarily, the limb becoming cold and weak. In the course of a few weeks pulsation probably will reappear and the parts return to the normal, while in any case a collateral circulation is rapidly formed, sufficient to preserve the vitality of the limb unless the patient is old or the vessels very diseased. Gangrene is not likely to occur in this condition, as, if the vessel becomes obliterated, it does so gradually as the result of thrombosis, and not immediately the injury is received.

(*b*) **Complete Rupture.** In this case all the coats of the vessel are torn across, so that immediate escape of blood into the surrounding tissues occurs. The escape of blood is not, however, as free as might be expected, as the inner and middle coats usually give way at a higher level than the outer coat, and they may curl up and partially obstruct the vessel, while there may be sufficient shock associated with the injury to cause the blood pressure to fall considerably. This condition is most commonly seen in the popliteal artery in association with a fracture of the femur, in the axillary artery in connection with a dislocation of the shoulder, or in the middle meningeal vessel. The extravasation of blood forces the tissues apart so that a large cavity, filled with fluid blood and soft clot, is formed. This condition is sometimes named a "*diffuse traumatic aneurysm,*" but this is not a good description, as there is no true aneurysmal sac. The tissues around the swelling become matted together and fibrin becomes deposited upon them, so that in a short time a firm fibrous surrounding capsule is formed. The shape and size of this swelling depend almost entirely upon the resistance of the surrounding structures and tissue planes; though in most instances the swelling forms rapidly, in other cases the hæmorrhage appears to be delayed for some hours, owing possibly to blocking of the vessel, and it is only later, perhaps after some incautious movement, that the swelling appears. The symptoms of this condition are similar to, but very much more severe than, those of the previous one; for the pain and swelling are very much greater and the patient will often state that at the time he felt a snap as though something had broken. The loss of pulsation and power and the coldness of the limb are also very much more marked. The swelling is tense, exceedingly tender, and firm to the touch; distinct expansile pulsation is present, and there will often be a thrill and bruit, while the swelling cannot be reduced on pressure as can an ordinary aneurysm, nor is it wise to attempt to do so. In the course of a few hours or days, as more fibrin is developed, it becomes harder, and the pulsation and bruit will often disappear. The swelling usually presses upon surrounding veins and leads to congestion, cyanosis and œdema of the limb beyond it, while after a few days extensive bruising of the surrounding skin may appear. The distal pulse will disappear completely, while numbness, tingling, and even total anæsthesia often will be found. This is partly due to the deficient circulation and coldness, but in many cases the effused blood will press on important nerves. In other cases the nerves themselves may have been torn at the same time as the vessel. The pulsation will cease, of course, if the main vessel be compressed above the injury.

Gangrene of the limb is much more likely to follow a complete than an incomplete rupture, on account of the pressure exerted upon the collateral vessels by the swelling and the fact that the blood supply is instantly cut off. In other cases the skin will slough on account of its distension, and then a violent secondary hæmorrhage may set in, while it is sometimes found that the blood will track into the pleura or peritoneum, and the patient may die of internal hæmorrhage. The pressure of the swelling even may cause damage to important organs, as in the case of the brain. Infection and suppuration are not likely to occur unless there is a breach of the external skin surface or unless the skin sloughs later. In many cases, after a short time the swelling ceases to increase in size owing to the deposit of fibrin on its wall, the mouth of the vessel becoming blocked, and in this case in the course of some weeks a spontaneous cure may occur, the swelling being gradually absorbed or possibly persisting as a blood cyst, while the vitality of the limb is preserved. In other cases the condition will pass gradually into a true traumatic aneurysm, the wall of the cavity gradually becoming converted into firm fibrous tissue and in course of time acquiring an endothelial lining, whilst the opening into the vessel remains patent. For the course and treatment of this condition, see p. 277.

Treatment. If possible the treatment in the first instance should be expectant, and the limb should be placed in such a position that the venous return is encouraged without the arterial circulation being hindered. The whole limb should be wrapped in cotton wool and a careful watch kept on the size and tension of the swelling, and for possible signs of gangrene. In many cases, with this treatment, the acute stage will pass off, and in the course of six or eight weeks either complete recovery or the formation of a traumatic aneurysm will have occurred. If, however, the swelling is very large and tense, so that the skin looks as though it might give way, and the limb appears to be verging on gangrene, operation will have to be undertaken in order to relieve the tension and to try to restore the continuity of the artery. The circulation of the limb must be controlled temporarily by a tourniquet, if possible, or otherwise by digital pressure or a temporary clamp or ligature upon the main vessel above the swelling, and the extravasation should then be cut down upon, the clot cleared away, and the vessel exposed above and below the injury. If the circulation cannot be controlled above the sac by any of the methods above described, the sac must be boldly and quickly opened and two fingers rapidly introduced to stop the hæmorrhage, but this is a procedure by no means devoid of risk. Having exposed the rupture in the vessel, an attempt may be made to restore the continuity of the vessel itself, either by end-to-end anastomosis or lateral suture, and there are various methods of doing this (see p. 290). In many cases this will be impossible ;- for instance, the vessel may be too small, the damage be too extensive, the exposure not sufficient, or the patient's general condition too bad. If for any of these reasons suture is impossible, each end of the vessel should be ligatured. Momentary relaxation of the tourniquet may be necessary to enable the ends to be found. If the ends cannot be discovered even then, the main vessel should be ligatured a short distance above, but this is to be avoided if possible, as it is followed by a risk of secondary hæmorrhage. If gangrene sets in or severe secondary hæmorrhage occurs, amputation will have to be done.

Open Wounds of Arteries. These may be lacerations, punctures, incised wounds or gunshot wounds, and it is not necessary to draw hard and fast distinctions between them. All such wounds will be followed by hæmorrhage of very varying degrees of severity, and in some cases, if the external opening in the skin is small and the wound valvular, the blood may not be able to escape externally. The amount of hæmorrhage also will depend upon the size of the vessel damaged, the nature of the wound, and the amount of contraction and retraction of the vessel coats which can take place.

Lacerated wounds of the vessels usually occur in explosions, crushes, and machinery and railway accidents. Injuries of this kind, and even the complete tearing off of a limb, are often accompanied by surprisingly little hæmorrhage, as the vessels are torn, twisted or crushed, and they therefore become blocked by contraction and clot formation much more quickly than if they were cleanly incised.

An incised wound of an artery usually only divides the vessel wall incompletely. If it is longitudinal, there is little gaping and not much hæmorrhage, but when the incision of the vessel wall is transverse or oblique the retraction of the muscular and elastic tissues makes the opening gape and become larger, so that hæmorrhage will be particularly free and may prove dangerous, even in the case of a small vessel. If the artery is completely cut across, the hæmorrhage will be copious in the case of a large vessel, but in a small vessel the contraction and retraction of its walls will cause it to cease rapidly. All such incised wounds in an arterial wall usually heal quickly unless infection is present. In this latter case there is a grave danger of secondary hæmorrhage, while in any case they are liable to be followed after an interval by the formation of an aneurysm. Though the hæmorrhage from a wound in an artery has usually the characteristics of an arterial hæmorrhage (see p. 47), this is not always the case if the patient is deeply shocked, if the external wound is small, or if the vessel is very deeply placed ; while if the patient is cyanosed the blood flowing from an artery will be very dark in colour.

A punctured wound of a vessel will vary greatly, according to the size of the body which produces it. If the condition is a minute puncture with a needle, as in the case of needle explorations or injections, there is practically no hæmorrhage at all on account of the elasticity of the vessel wall, and no evil results will follow, as the wall will heal rapidly and firmly by the formation of a small thrombus over the puncture. In the case of larger punctures, however, such as those due to stabs or operation wounds, the condition is comparable to an incomplete incised wound, so that the contraction and curling up of the intima and media cannot take place and hæmorrhage may be free. In many cases the pressure of blood effused into the surrounding sheath and tissues will control the hæmorrhage after a time, as a clot will form in the gap in the vessel wall without blocking its lumen, and the wound in the wall will ultimately heal. Many other cases are followed by the formation of a traumatic aneurysm, while if infection occurs there is always grave danger of secondary hæmorrhage. These wounds are frequently seen at the wrist from broken glass, especially in girls who work in bottling factories. The radial or ulnar artery is then usually involved, and here the formation of a small localised aneurysm is a common sequel.

In war-time *gunshot wounds* of the vessels are common. In the case of shell injuries the wounds are usually ragged and extensive, and fall under the heading of lacerated wounds, while infection is usually severe; but in the case of high-velocity conical bullets the injuries are usually true punctured or incised wounds, though in many cases the tense and elastic artery rebounds from the force of the projectile and escapes any injury in a miraculous manner. The amount of external hæmorrhage depends largely upon the size of the skin wound, and in the case of a small punctured bullet wound it is often very slight; and it sometimes happens that quite a large artery is perforated by a bullet without very much harm being done. Traumatic aneurysms of various kinds and arteriovenous aneurysms (pp. 276, 279) are particularly liable to follow gunshot wounds of arteries; in fact, cases have been recorded in which a bullet has perforated both walls of an artery and two separate aneurysmal dilatations have formed, one in connection with each opening. Other cases of arterial wounds, where the external opening is small, will be followed by the formation of a firm, pulsating hæmatoma with a bruit and thrill, and in this case the condition will very closely resemble that seen after a subcutaneous rupture (see p. 256), though here the chances of infection are much greater, as there is an external wound, and a foreign body has entered.

Veiy occasionally incomplete wounds of big vessels are seen in which the outer or outer and middle coats only are damaged. When this occurs there is no bleeding from the vessel, but the intima will bulge out and a traumatic aneurysm is almost certain to form later.

In any case of arterial wound gangrene may set in in the limb beyond. This will depend upon the size and nature of the wound, the particular artery concerned, the question whether its accompanying vein is wounded as well, the general state of the patient and of his arteries, and other causes. In other instances, though gangrene is averted, the signs of ischæmia may develop, and there will then be an anæsthesia of a "stocking" type, tickling and pricking sensations, while the muscles become hard, rigid and paralysed, so that the limb becomes stiff and motionless.

Treatment. Any wound which appears to involve a big artery must be explored under an anæsthetic, the wound being enlarged if necessary.

The treatment of a lacerated arterial wound is that of wounds in general (see p. 41), special attention being paid to the ligation of the vessels concerned and the prevention of infection. It must be remembered that in most cases it will be necessary to ligature both ends of the vessel, and this should always be done as near as possible to the site of the injury.

In the case of an incised wound of a large vessel, if it is thought that there is a reasonable chance of the wound healing by first intention and the vessel wall appears healthy, an attempt should always be made to suture the opening (arteriorrhaphy), while to control the hæmorrhage temporarily until the operation can be performed, pressure or a tourniquet must be employed (see p. 272). There are several methods of doing this, according to the nature of the wound in the vessel and the sutures employed (see p. 290). If the wound heals by first intention after this has been done there is very little risk of secondary hæmorrhage, though thrombosis is not unlikely; but if the latter should occur it leads to a gradual obliteration of the vessel instead of to the sudden stoppage caused by ligature, and there is, therefore, much less likelihood of gangrene. In the case of smaller arteries or if suture seems impracticable, the vessel must be tied above and below the wound and then cut completely across between the ligatures.

The treatment of a punctured arterial wound consists in enlarging the wound in order to expose the vessel, this being done with a tourniquet in position. Here again the opening should be sutured if possible, but if this cannot be done the vessel is ligatured above and below the puncture. It must not be forgotten that any branch which may arise between the ligatures will have to be tied also. As a general rule it is unlikely that suture of wounds which run transversely across the vessel wall will be as successful as in the case of longitudinal wounds. Ligature of the main vessel at some distance above the injury should never be performed if it possibly can be avoided.

The immediate treatment of wounds of this kind and the various methods which may be employed to arrest hæmorrhage are fully described on p. 41 (see also Appendix).

Arteriovenous Wounds. Any wound which involves both an artery and a vein lying in close contact with each other is liable to be followed by an arteriovenous communication (*aneurysmal varix or varicose aneurysm*) (see pp. 277, 278), and this is especially liable to follow a punctured wound with a small opening in the skin. These conditions are specially common after stab wounds and high-velocity bullet wounds, and they are most commonly seen between the brachial artery and basilic vein (this was more common in the days of bleeding at the bend of the elbow), between the carotid and internal jugular, in connection with the femoral vessels, and occasionally between the internal carotid and the cavernous sinus. Nor are they necessarily confined to the large vessels, for they have occurred in connection with the facial artery, the arteries of the orbit, the transverse cervical artery, and even smaller and unnamed vessels. These communications are frequently formed immediately after the wound, without any hæmatoma or extravasation, while in a wound which is going to develop one of these conditions it is most unusual for there to be a large swelling at the time of the original injury. It is probable that if extravasation occurs into the tissues the pressure of the extravasated blood occludes the vein, so that no arteriovenous communication can form, and the result is then likely to be a true traumatic arterial aneurysm.

DISEASES OF THE BLOOD VESSELS

Although the processes of thrombosis and embolism are very often due to causes not connected with the blood vessels, and are intimately associated with diseases of other organs, it is convenient to describe them here, as the pathological symptoms they cause are due almost entirely to their effect on the vessels. These two conditions affect both arteries and veins, and the first is often the cause of the second.

Thrombosis. Thrombosis is the process of formation of a clot within the cavity of the heart or of a blood vessel, the clot thus formed being known as a *thrombus*. There are three chief predisposing causes of thrombosis :—

1. Any interference with the smoothness or normal condition of the endothelial lining of a vessel wall, due to disease or injury ; thus it is often seen in atheroma and phlebitis.

2. Any cause which leads to slowing or stagnation of the blood stream ; this probably does not play a very important part.

3. Certain alterations in the condition of the blood itself, which are due to toxæmias of various kinds and which increase its powers of coagulation.

A thrombus may be of two kinds. When it is formed slowly, as is the case in the sac of an aneurysm, it consists of fibrin and leucocytes without any red corpuscles, and it is often then deposited in layers, so that it appears to be laminated, while it is white or grey in colour : this is a **white thrombus.** The other kind is seen when the clot is formed rapidly in a vessel where the blood is almost motionless, so that all the elements of the blood are present in the clot, which is then known as a **red thrombus.** This variety is most commonly seen after ligature of a vessel or in varicose veins, while it is by no means uncommon to meet with thrombi which can be described only as mixed thrombi, both white and red portions being present, often in alternate layers. White thrombi are generally firmly attached to the vessel walls, while red thrombi are quite loose. Veins are much more often affected by thrombosis than are arteries.

A thrombus may be either sterile or infected with pyogenic organisms, and in the former case its tendency is to become organised into fibrous tissue. Such a thrombus may not necessarily at any time completely block the vessel, and in the process of organisation it will shrink, so that even if the vessel were previously completely blocked, it may become canalised again. In other cases a thrombus will undergo fatty degeneration, or may become calcified. This latter process is especially seen behind the valves in veins, and in piles. Such a calcified thrombus will cast a shadow on X-ray examination, and in the pelvis will resemble a ureteric calculus : it is known as a **phlebolith.** In other instances portions of a thrombus will be broken off by the force of the blood stream and carried to other parts of the body in the circulation, to be deposited in smaller vessels as emboli (see below).

An infected thrombus does not organise at all, but softens, suppurates, and forms a localised abscess, which is first of all within the vessel wall, but ultimately involves this wall and spreads outside it. In this case portions of the thrombus are much more likely to be detached and carried away as emboli, and with these portions in their journey through the blood vessels are carried pyogenic organisms, which thus will reach distant parts of the body and give rise to secondary pyæmic abscesses.

If an artery is blocked by thrombosis the general blood pressure may rise considerably, and the anastomotic vessels in the neighbourhood will soon dilate to set up a collateral circulation. Gangrene is not likely to follow thrombosis, as the blockage of the vessel does not occur very suddenly. If a vein is obstructed by a thrombus, there will be marked changes in the limb below the point blocked, which are described on p. 281 (Thrombophlebitis).

Embolism. Embolism is the term applied to the condition when a solid or semisolid body is carried along in the circulation and ultimately becomes impacted in a blood vessel. The body is called an *embolus*, and it is in most cases a portion of clot detached from a thrombus. In other cases an embolus may consist of a portion of an atheromatous plate or of a fibrinous vegetation from one of the cardiac valves, while sometimes portions of malignant tumours (especially sarcomata) will form emboli, and by their lodgment in vessels at a distance from the primary growth they will lead to the formation of secondary metastatic growths. Fat embolism and air embolism also occur occasionally (see Chapter XXIV.). Very rarely parasitic emboli are found, consisting of the ova or scolices of Tænia echinococcus or of the filaria. As in the case of thrombi, emboli may be sterile or infected. Portions of crushed or lacerated organs, such as the liver, have occasionally been found as emboli in the veins, while instances have been recorded in which after gunshot wounds bullets or fragments of shell have been carried about in the blood stream.

Inasmuch as the general systemic veins get larger and larger as they leave the tissues which they drain, and approach the heart, emboli will never lodge in them, and the condition is thus only seen in arteries and in the portal system of veins. The symptoms produced, which may be very slight or very grave, depend upon the size of the embolus, the size and situation of the vessel blocked, and upon whether the embolus is sterile or infected. An embolus whose seat of origin is a peripheral vein will pass to and through the heart, and, naturally, will become impacted in some branch of the pulmonary artery, though it is possible that minute ones may pass through the capillaries of the lung and thus get back into the systemic circulation again. As it passes along the arteries, an embolus may lodge anywhere as the vessel diminishes in size, but its lodgment is especially prone to occur at a point where a big branch is given off, or where a vessel bifurcates, while minute emboli frequently will find their way into and become impacted in any system of end-arteries which they may encounter. When an embolus becomes impacted in a vessel, fibrin is deposited round it, and if it is not already completely blocked the vessel rapidly becomes so. The embolus may then be regarded as being reconverted into a thrombus, and it may pass through the same changes as the thrombus from which it originated.

The changes in the peripheral parts beyond where the embolus is impacted vary greatly. In most cases there is severe pain at the site of lodgment and marked anæmia in the limb beyond. This may be all if the collateral circulation is good, but in other cases gangrene will follow rapidly. If the embolus is infected pyæmic abscesses are common, and in some cases the softening of the vessel wall produced will lead to an aneurysm. If the vessel blocked is a terminal artery or an end-artery,. death of some portion of the tissues supplied by that vessel is bound to occur. This in some instances may mean gangrene of a whole limb, while in an organ such as the kidney or spleen a wedge-shaped area of dead tissue will form with the obstructed artery at its apex, the condition being known as an **infarct.** Such an infarct is usually white and structureless, but if it is accompanied by great engorgement and extravasation of blood, it is of a dark purple colour, and is then known as an **hæmorrhagic infarct.** The symptoms of such an infarct will depend upon the organ in which it occurs, and its ultimate fate is to become invaded by granulation tissue, which organises and fibroses, so that the end result is a puckered white scar in the organ, with, at times, some crystals of hæmatoidin in it. Infarcts are only seen in the lungs, spleen, kidney and brain, and in this latter organ the results of an embolism lead more commonly to yellow or white diffuse softening. They do not occur in other organs, as the anastomosis is too free.

Infected emboli and multiple pyæmic abscesses are especially seen in connection with malignant endocarditis, acute osteitis and lateral sinus thrombosis. Emboli can at times be removed from an artery by the operation of embolectomy (see p. 158).

In the case of certain special organs, the symptoms of embolism are so grave and so characteristic that they require individual mention.

Pulmonary embolism (Chapter I., p. 16) is one of the most common forms, and it is most frequently seen after abdominal operations, especially perhaps after upper abdominal operations and prostatectomy. Some cases are instantly fatal, one of the main branches of the pulmonary artery becoming blocked; apart from these grave cases, many varying types of severity will be seen, ranging from those in which death occurs in a few moments, to others where the condition is trifling and transient. There are usually no signs pointing to a thrombosis of any vein, and the condition comes on suddenly and absolutely unexpectedly. It is not known for certain whether the condition is a true embolus (formed possibly in the auricle of the heart) or a spreading thrombosis. The symptoms produced are sudden, intense pain in the chest, which most commonly occurs one week or more after an abdominal operation, especially one where there has been some infection. More rarely this occurs later, when the patient is more or less convalescent, or it may follow some sudden injudicious movement.

Clinical Features. In many cases it has been noticed that the onset of the condition has been preceded by a few minutes by an intense desire for the bowels to act. When the embolus occurs there is great distress, dyspnœa and anxiety and much embarrassment and irregularity of the heart's action. Marked shock will be present, while later, if the patient survives, there will be a rise of temperature to 100° or 101° F., the pain will become less incessant, but will persist as a stabbing pain on respiration; there will be a cough, accompanied by a small amount of blood-stained sputum, while the physical signs will consist of a pleural rub and those of a small area of consolidation in the lung, surrounded by an area in which moist crepitations can be heard. In the mild cases there is no sputum and no physical signs can be discovered. If the patient lives a few hours the condition probably will pass off in the course of time, though if the embolus is infected there is a grave risk of a pulmonary abscess or an empyema developing.

The *treatment* of this condition consists in the administration of morphia and absolute rest; various symptoms must receive appropriate treatment as they arise. The operation of Trendelenburg has been devised (see Chapter XI., Vol. II.) for the removal of the clot from within the pulmonary artery, but this has rarely so far been performed successfully in this country. Morphia will be found to have a remarkable effect in relieving the patient's pain and anxiety and in improving the condition of the pulse.

In the **central artery of the retina** an embolism will produce sudden total permanent blindness, the retina appearing to remain viable, although its function is completely lost, and no treatment is of avail. On ophthalmoscopic examination the retina appears pale and œdematous, while the macula is unchanged.

In the brain the middle cerebral artery is most commonly affected, and in this case there will be a sudden hemiplegia, sometimes accompanied by temporary unconsciousness. Considerable recovery will occur from this hemiplegia in the course of time, though there are nearly always permanent effects left. The condition is here liable to lead to an aneurysm of the artery which may give further trouble.

In the **liver**, emboli are usually multiple and infected, being the result of a pylephlebitis (see Chapter XVIII., Vol. II.). When this occurs the liver rapidly becomes riddled with multiple pyæmic abscesses.

In the **spleen** and **kidney** there is a sudden sharp pain over the organ concerned, accompanied by a slight rise of temperature and swelling of the affected organ. In the case of the kidney considerable temporary hæmaturia occurs.

In the **intestine**, embolism of the mesenteric vessels may lead to gangrene, and it causes a form of acute obstruction which is described in Chapter XVI., Vol. II.

In the **limbs**, emboli are usually lodged at the bifurcation of the main vessels. The condition is not uncommon in the popliteal artery in cases of valvular disease of the heart, and when this occurs usually both branches of the vessel are blocked. The patient complains of sudden intense pain, followed by numbness and coldness of the limb below, while the site of lodgment is acutely tender. Recovery may ensue, but gangrene or the formation of an aneurysm are not uncommon. If such a case is seen early the vessel may be opened, the clot removed, and the vessel wall may then be sutured (*Embolectomy*, see p. 158); otherwise every effort must be made to encourage the circulation through the limb.

INFLAMMATION AND DEGENERATION OF ARTERIES

Arteritis, or inflammation of the wall of an artery, may be acute or chronic.

(*a*) **Acute Arteritis.** Bruising or injury to the vessel wall will be followed by a mild degree of traumatic arteritis, which is really an inflammation due to the processes of repair. A more serious form is the infective arteritis, which is due to infection of the arterial wall, caused by septic wounds, ulceration or abscess cavities around the vessel. This is especially seen when a drainage tube is pressing upon a vessel in a septic cavity. The arterial wall becomes hyperæmic and swollen; the three tunicæ become blended and softened, and may yield ultimately either so that an aneurysm forms, or give way completely and cause secondary hæmorrhage, while if the vessel is small, thrombosis will occur. The condition is seen occasionally in a mild and non-suppurative form in children, in whom it may give rise to an aneurysm, but the suppurative form, which leads to severe secondary hæmorrhage, occurs in abscess cavities, in phthisical cavities (where it is probably preceded by a minor degree of aneurysmal dilatation), and around vessels which have been tied in continuity with an infected ligature.

A similar process is seen in the wall of a vessel which is blocked by an infected embolus, and here gradual aneurysmal dilatation is considerably more common than suppuration. This is probably the only cause of a spontaneous aneurysm in young people. For a gradual aneurysmal dilatation to occur round an embolus it is essential that the infection should not be very virulent, as virulent organisms in the embolus probably will lead to suppuration.

(*b*) **Chronic arteritis** (endarteritis) is due to several causes. One of the commonest forms is that due to syphilis. In this case the tunicæ intima and externa are chiefly involved, the media escaping. The intima becomes much thickened and overgrown, so that the lumen of the artery becomes partly or completely blocked, and thus the condition is sometimes known as ***syphilitic endarteritis obliterans.*** The externa is also fibrosed and thickened, so that the vessel wall becomes tough and inelastic. This condition is specially liable to lead to the formation of an aneurysm, while the parts supplied by the diseased vessel suffer greatly in nutrition. The condition is usually seen in the tertiary stages, and frequently in the neighbourhood of gummata, while it is especially liable to affect the small arteries. It is the cause of the central sloughing which occurs in a gumma.

Chronic tuberculous endarteritis is a very similar condition met with in and around tubercles, and is especially seen in the lungs. It will be found in tuberculous granulation tissue, and spreads widely down the vessel walls.

Arteriosclerosis. The commonest and most important form of chronic arterial disease is arteriosclerosis. This is a frequent affection of the arteries, which is partly degenerative and partly inflammatory, and it gives rise to changes in the walls, which cause them to lose their elasticity, and which also lead to narrowing of the lumen. The primary cause of the disease is not known. It usually commences about middle life, and is almost invariably found to some degree in the aged, so that in these instances, at any rate, it appears to be a senile degeneration, and may be regarded as a more or less physiological process due to wear and tear. It is undoubtedly predisposed to by heavy muscular exertion, especially if intermittent, and by prolonged strain or overwork in any form. It is occasionally seen in younger patients, and in these cases and the more severe forms it is generally due to chronic alcoholism, diabetes, syphilis, gout, or lead poisoning. It is sometimes associated with the cachexia or malnutrition of malignant disease or tuberculosis, while in other instances it is a sequel of such general diseases as acute rheumatism, typhoid, or chronic Bright's disease. The condition may be either diffuse or localised, the two forms often coexisting in the same patient. There is a degeneration and loss of elasticity in the media and externa, which become tough and fibrosed, while the tunica intima undergoes an overgrowth or hyperplasia, the endothelium being specially proliferated.

(*a*) In the diffuse form it is the smaller vessels which are specially affected. Here the changes progress further and lead to extensive fibrosis and obliteration of the vessel lumen. The condition may advance even further, in which case the vessel walls, especially those of the limbs, become calcified by the deposit of calcium salts, so that the vessels themselves become converted into rigid hard tubes like pipe stems. When this occurs it will be followed by great malnutrition of the limb, which will be cold and anæmic and liable to abnormal sensations of pricking and tingling, and to muscular cramps and spasms ; these in the case of the legs may be the cause of sudden attacks of pain and lameness, known as *intermittent claudication.* Curious fibrillary twitchings of the muscles are often associated with this as well, while the condition not infrequently will be followed in time by senile gangrene. When present it renders ligature of the vessels unusually difficult, and the artery affected will be specially liable to rupture.

(*b*) In the localised form the condition is usually seen in the aorta and large vessels. Here the proliferated endothelium undergoes a secondary fatty degeneration, followed by the deposit of lime salts ; this process is not diffused throughout the whole wall, but occurs in patches, so as to give rise to the formation of hard, raised calcareous plaques on the intima. In time the endothelium over these plates disappears in a way that is not seen in the diffused form of the disease, and atheromatous ulcers will form, so that the plate will become actually exposed to the blood stream. This condition is known as **atheroma**, and is especially common on the arch of the aorta where the blood stream impinges, near the mouths of large branches, and at spots where large vessels are in contact with the bone or are continually being flexed by the movements of joints, while the presence of these patches in the arterial wall frequently gives rise to aneurysm formation or to traumatic rupture. The condition also predisposes the patient to thrombosis owing to the destruction of the endothelium, and this will carry with it an increased risk of embolism.

Arteriosclerosis is much more common and much more severe in men than in women. When it is marked, in addition to the blood pressure being much raised, superficial arteries, such as the temporal and radial, can be felt as firm, tough, rigid cords, even when emptied by pressure, while instead of running in their usual straight course they will become twisted and tortuous. When calcified they are so hard that the expression " pipe stems ", has been applied to them. It is not unusual to find that any such artery which is visible under the skin can be seen to move backwards and forwards with each cardiac pulsation, while when calcified the vessels may be clearly visible in an X-ray plate.

Simple atheroma often can be distinguished from a syphilitic arteritis by noting that the latter usually attacks the small vessels and affects their whole circumference, does not lead to fatty degeneration, and is more liable to cause total obliteration of the lumen.

In addition to its effect in producing surgical lesions of the arteries, it must be remembered that patients with arteriosclerosis are not good subjects for operations, on account of their high blood pressure and poor nutrition.

Preventive treatment in the case of arteriosclerosis is much more important and effective than is curative treatment. This is usually regarded as the province of the physician.

Thrombo-angiitis Obliterans (Buerger's Disease). This is a disease which causes an occlusive thrombosis in the deep arteries and veins of a limb following a subacute inflammatory process. Though usually seen in the legs, it has also occurred in the arms and even rarely in the spermatic cord. Its origin is unknown, though many theories are advanced to account for it. It is not syphilitic, and no organism has been definitely identified, while some observers believe it due to suprarenal hyperactivity and perform suprarenal excision for it. A large majority of cases have occurred in male Jews, usually between twenty and forty, while cigarette smoking has been thought to play a large part in its causation. It is seen in one or more limbs, and often involves both legs. When the spermatic artery is affected there is a subacute painless enlargement of the testis and epididymis closely resembling tuberculosis. The disease has been seen in the renal vessels.

Clinically, the first stage is generally an acute superficial phlebitis with swelling of the feet and later much pain in the leg. The pain soon becomes continuous and excruciating, and cyanosis, congestion, ulcers and gangrene occur sooner or later. The limb may be pale or blue, and is sometimes bright red.

Treatment. Amputation is almost certain to be necessary in the end, though hypodermic injection of Ringer's solution or sympatheticectomy may be beneficial. Excision of a suprarenal gland is disappointing, but good results have been reported from X-rays or injections of pilocarpine or insulin.

Amyloid disease of the vessels is not uncommon, and this is usually the spot where it makes its first appearance in the body.

TUMOURS OF BLOOD VESSELS

Tumours of blood vessels are common ; they consist of angiomata or nævi (which may be capillary, venous or mixed) and of cirsoid aneurysms, sometimes known as arterial angiomata ; very rarely sarcoma occurs in the walls of a vessel. For a full description see pp. 215—219.

ANEURYSMS

An aneurysm is a sac containing blood, which may be fluid or clotted, and which communicates directly with the interior of an artery. These may be divided into the two great groups of pathological (idiopathic or spontaneous) aneurysms, and traumatic aneurysms, while a further variety, which is always traumatic, consists of the various types of abnormal arteriovenous communications.

Pathological Aneurysm. The causes of this condition are two in number : firstly, changes in the vessel walls, which result in their becoming weakened, and less elastic, and, secondly, rise in the blood pressure ; in most cases these two conditions are found together and are mutually dependent upon each other. Thus arteriosclerosis and atheroma, especially if due to syphilis or gout, are the great predisposing causes, and these conditions usually will give rise to aneurysms in men of middle age, whose heart function and blood pressure show no signs of failing. In addition to this, a life of heavy strain and exertion, especially if intermittent, is another predisposing cause, but there is no evidence that steady muscular effort or regular exercise can be held responsible, and it appears that it is the repeated and sudden raising of the blood pressure that does the damage. The condition is seven times more common in men than in women, is most frequently seen in sailors, dock labourers, and navvies, and usually between the ages of thirty and fifty. It is more common in the northern and colder parts of the world than the south, and especially is it seen among the active Anglo-Saxon race. Syphilitic infection has a very great influence upon the formation of aneurysms ; it is found to be present in over 75 per cent. of cases, and it probably produces its effect by the way in which it affects the vessel walls in the form of a syphilitic arteritis (see p. 264). It is most unusual to find an aneurysm in a woman unless she is syphilitic.

The comparative frequency of aneurysms in such vessels as the popliteal and lower part of the brachial suggests that possibly the continual flexion and extension movements of the joints may be a predisposing cause in weakening the vessel wall.

In some cases the lodgment of an infected embolus in an artery will give rise to a softening of the vessel wall, and thus lead to an aneurysm. This variety will be seen most commonly in young patients with valvular disease of the heart. It is also not uncommon in malignant endocarditis, pyæmia and septicæmic conditions.

Three chief varieties of aneurysm are seen ; the fusiform, the sacculated, and the dissecting.

(*a*) **Fusiform Aneurysm.** In this variety the whole circumference of the vessel has been weakened, and thus the vessel walls expand more or less uniformly, to give rise to a swelling of spindle or tubular shape and in direct continuity with the arterial length. All the coats of the vessel are stretched and thickened and play their part in forming the sac, and the affected portion of the vessel is increased in length as well as dilated, while the condition is generally due to extensive disease of the vessel wall and never to injury ; it is usually seen in the arch of the aorta and other main trunk vessels. The tunicæ intima and externa are specially thickened and strong, while the former may be roughened and atheromatous. Such an aneurysm, therefore, usually increases in size very slowly, and does not give rise to urgent symptoms, though in time it may become enormous and produce serious pressure in all directions. The blood in such a sac is usually fluid, and there is little tendency for it to clot on the vessel wall, so that a natural cure is most unlikely, and can be achieved only if the artery becomes blocked by a clot. Nor is a spontaneous rupture common, unless, as is occasionally seen, one portion of the wall dilates more rapidly than another, in which case the aneurysm really passes into the next variety.

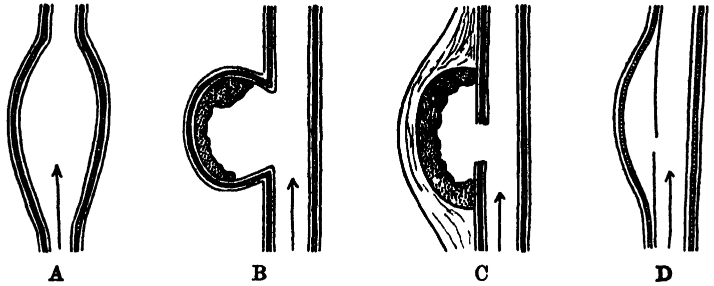


FIG. 158. Varieties of aneurysm: A. Fusiform aneurysm. B. Sacculated aneurysm. C. False aneurysm. D. Dissecting aneurysm.

Occurring as they do nearly always in the thorax, these fusiform aneurysms are not often seen in surgical practice, and their diagnosis and treatment belong more properly to the domain of medicine. Efforts have occasionally been made to treat them by wiring (see p. 275).

(*b*) **Sacculated Aneurysm.** This form arises when a localised weak patch in the vessel wall yields, and the swelling does not therefore, at first at any rate, involve the whole circumference of the vessel, but bulges out from one side. It is not in direct line with the remainder of the vessel, but communicates with the interior of the artery by a comparatively small lateral opening of varying size. Being due usually to injury or to local extensive disease in the vessel wall, the intima and media are commonly more or less destroyed, and the sac is therefore formed entirely of the externa, which becomes greatly thickened and adherent to the surrounding tissues. The sac wall in this variety also becomes strengthened by the formation of a layer of laminated clot on its interior, which in time will become organised into fibrous tissue. All traumatic aneurysms are of this variety; sacculated aneurysms will be found much more commonly on the limbs than in the trunk, and increase in size much more rapidly than fusiform aneurysms; they often end in rupture, while the pressure of the sac leads to great matting of the tissues around, and the wall forms firm adhesions to important tendons, muscles and nerves. The sac contains blood which is partly fluid and partly clotted, the clot being deposited in circular layers inside the cavity. At the central portions the clot is softer and redder than at the periphery, and not only does this clot strengthen the sac wall, but in some instances by increasing in size slowly and filling the cavity it will bring about a natural cure. Thus a sacculated aneurysm is more liable both to spontaneous cure and to rupture (or to diffusion, in which case the blood leaks gradually out into the surrounding cellular tissues) than is the fusiform variety. It is also much more amenable to surgical treatment.

(c) **Dissecting Aneurysm.** In this case the wall of an artery is split into two layers by the blood forcing its way into the actual tissues forming the wall, and distension of the vessel follows. This line of cleavage usually passes through the middle of the media, the blood entering through an atheromatous ulcer, so that the result is a cavity formed within the vessel wall, lined on its outer side by the externa and part of the media, and on its inner side by part of the media and the intima. The condition is rare, and is only seen where the vessel wall is extensively diseased with atheroma, and then only in the aorta. These swellings are not, as a rule, very big, and their tendency is to spread and burst. They do not enter into the realm of practical surgical treatment.

An aneurysm is called *internal* when it lies in the thorax or abdomen, and *external* when in the neck or limbs ; it is known as a *true aneurysm* if the sac consists of the real walls of the vessel altered or distended, and as a *false aneurysm* if the sac is formed by condensation of the surrounding tissues—the latter variety are usually traumatic.

Clinical Features. This description refers almost entirely to external aneurysms, and the signs and symptoms fall naturally into three groups, the local, the distal, and the general; it must be remembered that of the aneurysms seen by the surgeon, the sacculated variety is by far the commonest and most important. The most prominent feature is the presence locally of a smooth, rounded, painful swelling in the line of an artery, which exhibits true expansile pulsation, synchronous with the heart beat. By expansile pulsation is meant the fact that the tumour increases in size in all directions at each beat, and is not merely pushed forward, so that if two fingers are placed upon the swelling they will be seen to be separated from each other with each pulsation. If the main artery proximal to the aneurysm is compressed the pulsation is diminished or arrested, and the tumour becomes less tense and smaller, this diminution in size being, however, more marked in the case of fusiform aneurysms than sacculated ones. The swelling may be reduced in size by gentle pressure, and if this is done while the vessel is compressed proximally, a very marked reduction in the size of the swelling (depending upon the amount of clot) will be produced, while when the compression of the vessel is released, the tumour rapidly regains its former size and tension, in a series of two or three bounds, synchronous with two or three heart beats. In some cases pressure on the main vessel distal to the sac will increase the tension and pulsation. Such a tumour can be moved transversely across the limb, but not longitudinally, while it cannot be lifted away from the artery to which it is attached. It is often found that on light palpation a marked thrill is present, while a rough blowing, systolic murmur is almost invariably heard. This murmur will be found to be conducted up and down the vessels in a most remarkable way, often being conducted right up a limb to the trunk. It is usually loud and harsh, occasionally musical, sometimes double, and may be heard by the patient. This bruit is most noticeable in the fusiform variety. In the sacculated form not only may the bruit be absent, but when there is much clot in the sac, and the opening into the main vessel is small, pulsation may be very slight also. If the sac becomes full of clot (**consolidated aneurysm**), all these signs will disappear and the tumour will become a solid one, only receiving a transmitted pulsation from the vessel to which it is attached. Aneurysms always cast a shadow in an X-ray plate, and sometimes this will help to distinguish them from other swellings. Nearly every aneurysm is accompanied by a certain amount of cardiac enlargement.

Distally it will be found that the circulation in the limb is defective, while on comparing the pulses in two corresponding vessels on opposite sides, one distal to the aneurysm and the other on the sound side of the body, it will be found that the pulse on the side of the aneurysm has a wave which is delayed and of smaller volume, while a pulse tracing will show that the dicrotic wave is lost and that the force of the tidal wave is diminished. This alteration in the pulse is due partly to intervention of the aneurysmal sac in the course of the vessel and to obstruction from that cause, but it must be remembered that the sac also may press upon the main trunk of the vessel or upon surrounding collateral vessels, which are endeavouring to keep the circulation going, and thus the vitality of the limb may be greatly endangered. As it increases in size the aneurysm will exert great pressure upon the surrounding structures, so that the tissues become thickened, matted and adherent to the sac. Thus pressure upon the veins will produce congestion and œdema of the distal parts of the limb, and this may be assisted by a local thrombosis in the vein. Pressure upon important nerves will produce referred pain, alteration of sensations, and paralysis of muscle groups, sensory changes being more common and severe than motor effects. Muscles are displaced and fibrosed, whilst the bones, if pressed upon, are rapidly eroded and may be extensively damaged; this is especially seen in the case of the sternum and vertebræ, the commencement of pressure upon bone being indicated by constant deep pain. A spontaneous fracture may be caused in this way. It will be found that cartilage yields before the pressure on account of its elasticity, and is much less eroded than is the hard, resistant bone. Thus intervertebral discs or costal cartilages are very little affected, while the vertebræ or ribs may be completely destroyed. In time the skin over an aneurysmal swelling will become stretched and thin; it may slough and give way, and then disastrous hæmorrhage will follow.

The tissues round an aneurysmal sac which has been present for some time become thickened and matted by a plastic inflammation. This may give rise to considerable local pain at the site of the swelling, as well as to pain referred down the nerves.

Arteriography can be resorted to with advantage in obscure cases and those of internal aneurysm.

With regard to the general effects of an aneurysm, there is always a certain amount of compensatory enlargement of the left side of the heart and a systolic murmur is frequently present there. This may be in some instances the murmur of the aneurysm conducted to the heart up the vessels. Small portions of clot will be broken off sometimes by the blood stream and be carried about in the circulation as emboli, when they may lead to very serious complications, such as gangrene or cerebral embolism. On the other hand, if an embolus blocks the main vessel just beyond the aneurysm it may lead to a permanent spontaneous cure.

Differential Diagnosis. As pulsation is so striking a feature of an aneurysm, a differential diagnosis has to be made only from other pulsating swellings. Any swelling pressing upon or in the neighbourhood of a large artery, such as a mass of glands, a cyst, abscess or growth, may derive a transmitted pulsation from the vessel, but such a transmitted pulsation is not expansile, and two fingers laid upon the swelling will not be moved apart. Such a pulsation ceases when the artery is compressed proximally to the swelling, but there is no diminution in the tumour's size and tension. When the compression is released and the pulsation returns, it does not do so in successive leaps, as in the case of an aneurysm, but returns in full at once; in many cases the swelling can be pushed aside that it no longer lies over the artery, and in this case there will be no more pulsation. There may be no alteration in the distal pulse, though it must be remembered that when such a tumour is pressing upon a vessel, a bruit, thrill or alteration in the distal pulse may be present.

In other cases an artery may be pushed forward by an underlying swelling and give rise to marked pulsation in an unusual situation; but here the pulsation will be limited to the line of the vessel, while the swelling itself underneath will not pulsate.

Certain very vascular tumours, such as bone sarcomata, nævi and goitres, may exhibit true expansile pulsation, with a soft bruit and sometimes a thrill. The pulsation, however, is not so forcible, nor does the swelling usually lie over the line of a big vessel. Such a swelling cannot be emptied by pressure, nor is it diminished in size when the artery on the cardiac side is compressed; moreover, it is of irregular consistency, and has not the smooth, rounded outline of an aneurysm. An X-ray plate probably will distinguish a sarcoma.

Inasmuch as the pain of an aneurysm is often referred to the distal parts of a limb, the condition is sometimes missed and the pain thought to be due to neuralgia or sciatica. In nervous women, especially those with visceroptosis, a marked pulsation is often seen in the epigastrium; but there is no true swelling, and the condition, which is simply due to the aorta, must not be mistaken for an aneurysm.

Prognosis. **Spontaneous cure** occasionally but rarely occurs in sacculated aneurysms, never in fusiform ones. This is usually brought about by a formation in the sac of clot which slowly increases in size, fills the sac and closes up its opening. In some instances this process is greatly assisted by an embolus lodging at the opening of the sac or in the main trunk of the vessel beyond the aneurysm, so that the circulation is temporarily completely stopped. In other instances the sac has become so large that it presses upon the main vessel, either above or below it, and thus causes the circulation to cease. When a natural cure is in process the sac becomes smaller, harder, less compressible, and pulsation becomes less marked, as also do the bruit, the thrill, and any pressure and general effects. If this process is successful, in time pulsation will disappear completely, and the aneurysm will be replaced by a firm, solid, fibrous swelling, attached to the vessel (**consolidated aneurysm**). During this process the main trunk of the vessel is almost certainly obliterated and a collateral circulation will have become established.

Most aneurysms, however, will progress, and in time prove fatal if treatment is not provided. This fatal result will be due in some cases to pressure upon important structures, and this is seen in the brain, the neck or in the case of thoracic aneurysms. In other instances **suppuration** may occur, but this is very rare. In most cases such a suppuration starts primarily in the tissues outside and around the aneurysm and involves the aneurysmal sac secondarily, though the presence of an infected embolus may cause the sac itself to suppurate. When this occurs all the signs of abscess formation will be present, but such an abscess cavity will contain a mixture of blood clot, pus, and fresh blood. Such a swelling may point and may burst, while occasionally one has been incised by an unwary surgeon. In all such cases, either primary or secondary hæmorrhage is exceedingly severe.

The most common cause of death is, however, the **rupture of the aneurysm**, which is the result of the walls yielding from injury or over-distension. If the hæmorrhage takes place into the cellular tissues, the skin over it being intact, the process is known as **diffusion of the aneurysm,** and the extravasated blood will spread far and wide, exerting great pressure on the surrounding structures.

If an internal aneurysm ruptures, profuse hæmorrhage will take place into such parts as the pleura, the peritoneum, or the mediastinum. There is a sudden sensation of pain and the patient becomes pale, cold and faint and dies soon. In other cases the rupture will occur into the trachea or œsophagus, when there will be profuse hæmorrhage from the mouth and the patient may be drowned. In the case of an external aneurysm the process of rupture may be rapid or slow. In some cases the blood leaks out slowly, and the tumour gradually increases in size and alters its shape, while the pressure upon surrounding structures will gradually and steadily increase. If the rupture is sudden and more extensive there is severe pain at the site and the limb rapidly becomes tense and swollen ; all pulsation ceases and soon the limb will become gangrenous. In other cases the tension and pressure on the skin will cause it to slough and profuse hæmorrhage will follow. It occasionally happens that an aneurysm ruptures primarily through the skin or through a mucous membrane. When this occurs the patient dies after a few seconds of profuse hæmorrhage.

Treatment. The treatment of an aneurysm is both general and local.

General treatment should be applied in the case of every aneurysm, and in the case of thoracic aneurysms and many abdominal ones this is the best that can be done. In the case of external aneurysms in the neck and limbs it may be employed as an accessory to surgical measures directed against the aneurysm itself. The constitutional treatment of the aneurysm aims at diminishing the blood pressure and the force of the heart's action, and this consists in absolute rest, both mental and physical, with attention to the bowels and general health. The diet must be dry and non-stimulating and reduced to an absolute minimum, while watery purges are employed freely. Potassium iodide will be found valuable in full doses, for not only will it diminish the blood pressure and the action of the heart, but it is beneficial to the syphilitic infection, which is responsible for most cases of aneurysm. The pain and restlessness may require morphia, and this also will diminish the patient's desire for food, while if the patient appears to be full-blooded, venesection will occasionally be advisable. Calcium lactate (grs. viij t.d.s.) may improve the coagulating powers of the blood. In most cases, however, very little can be hoped for from constitutional treatment alone, and surgical treatment in the form of operation directed upon the aneurysm should always be performed if possible. This is nearly always feasible in the limbs or neck, and according to the situation and size of the aneurysm it may be an easy or a most formidable undertaking.

Local treatment consists of the application of one of the methods indicated below, and inasmuch as aneurysms are now rarely seen except in wartime the particular treatment for individual aneurysms is not dealt with here. For these the reader should consult earlier editions of this work, or the special appendix on war surgery.

Operations for the relief of aneurysms are of many different kinds, and may consist in excising the sac, in incising and obliterating it, in ligature of vessels, or the introduction of foreign material into the aneurysm to promote clotting.

(1) The ideal operation is that which was described by Matas, of New Orleans, as **endo-aneurysmorrhaphy.** This consists in exposing the aneurysm, opening the sac and introducing sutures in such a way that the opening into the vessel is tightly sewn up without occluding the original lumen of the artery. In addition to this the sac of the aneurysm, when emptied of clot, is folded by sutures in such a

way that no free space is left. This operation is known as **restorative endo-aneurysmorrhaphy**, and is, of course, only applicable to the case of a sacculated aneurysm with a small lateral opening into the vessel. In the case of a fusiform aneurysm, Matas has suggested two other suturing operations—**reconstructive endo-aneurysmorrhaphy** in which the sac is opened and sutures are introduced into it in such a way that not only is its space obliterated, but a new lumen is formed for the artery, and **obliterative endo-aneurysmorrhaphy**, where the sutures are introduced with the object of completely obliterating the aneurysmal sac and permanently occluding the lumen of the vessel. A full description of these operations will be found on p. 290. These procedures are ideal in that they aim at removing the aneurysm without occluding the lumen of the vessel, but it will be found in practice that there are very few cases in which they are suitable, for suturing of this kind is impracticable if the vessel wall is extensively diseased, while special apparatus and technique are required. Even if successfully performed, their results are not always good, for thrombosis of the vessel is very liable to follow after the operation, and in other instances a weak spot remains, which subsequently dilates so that the aneurysm reforms. Traumatic aneurysms (see p. 276) will be found to lend themselves more readily to this procedure than do pathological ones. It is, of course, only possible to perform any form of endo-aneurysmorrhaphy if the circulation through the sac can be temporarily controlled first. This must be done before the operation is commenced, either by a tourniquet, or by means of a clamp or temporary ligature placed on the main vessel above the sac.

(2) The next best operative procedure, and one which is more commonly feasible, and therefore more often performed, is known as **extirpation of the sac.** This consists in excising the aneurysmal sac bodily, as if it were a tumour, the artery being first ligatured immediately above and below, while any lateral branches which enter the sac will require ligature also. This can sometimes be done without opening the sac, while in other cases it will be easier if the sac is first opened and the clot turned out. If possible a tourniquet should be used during the operation, while it is essential for its performance that, if a tourniquet cannot be used, temporary complete control of the main vessel above the sac should first be attained, either by means of a temporary ligature or a clamp. The removal of the sac may require a complicated and difficult dissection; the accompanying vein very likely will be adherent and may have to be removed, but an efficient collateral circulation has probably been established weeks or months before, both arterial and venous, and no harm is likely to follow. The results of the operation will be found to be most satisfactory, since there is no chance of recurrence and gangrene is unlikely, for only one collateral circulation is required, namely, that immediately around the aneurysm. It is sometimes possible to restore the continuity of the artery, temporarily at least, by introducing a graft of a portion of a vein or a small metal tube, but this is not necessary. This method is applicable to all aneurysms of the limbs or neck, provided the sac is not too large and that control can be obtained of the main artery proximal to the aneurysm.

(3) Another rather similar operation of great antiquity, and known as the **old operation, or the operation of Antyllus,** consists in opening the sac, turning out the clot and ligaturing the vessel immediately above and below it, any branches entering the sac also requiring ligature. No attempt is made to excise the sac wall; the sac is either sutured together or left open, packed with gauze, and allowed to heal by granulation. This operation is one of much less magnitude than the last, but is by no means free from the risk of profuse primary or secondary hæmorrhage and of recurrence.

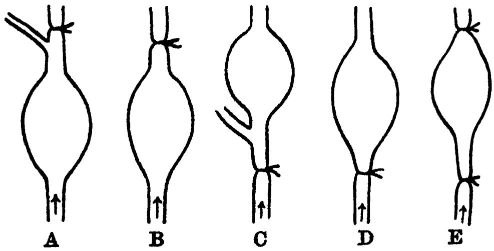


Fig. 159. Methods of applying a ligature in the treatment of aneurysm: A. Distal ligature of branches (Wardrop). B. Complete distal ligature (Brasdor). C. Proximal ligature at a distance (Hunter). D. Proximal ligature (Anel). E. Ligature above and below the sac.

Other methods of surgical treatment of aneurysm aim at encouraging the formation of clot within the sac in order that by its organisation it may obliterate both sac and artery, and these methods still have to be employed frequently.

(4) The chief of these methods consists in **ligature of the artery** in various situations. Such an arterial ligature for aneurysm may be proximal or distal to the sac, and there are two chief forms of proximal ligature.

(*a*) **Anel's operation** consists in tying the main vessel on the proximal side immediately above the sac, no branch intervening. This is occasionally practised nowadays, and may be regarded as free from the risk of gangrene or of secondary hæmorrhage. It is, however, by no means certain of curing or improving the aneurysm, as the blood will often find its way back into the sac through the other end of the main vessel or by a collateral branch, for it must be remembered that there is certain to be a free collateral circulation. It is by no means always as easy to perform as it sounds, for the proximity of the aneurysmal sac displaces the vessel and mats all the structures around it, so that the artery may be very difficult to identify, and may be diseased when found.

(*b*) **Hunter's Operation.** This is also a historic operation, being practised by John Hunter in 1785, about seventy-five years after Anel's operation. It consists in ligation of the main vessel at some distance above the sac, with one collateral branch intervening, and it ensures, at any rate, that the artery is ligatured at a spot where it is healthy and not disturbed by the sac itself. Its best example is ligature of the femoral artery in Scarpa's triangle or Hunter's canal for a popliteal aneurysm. This operation does not aim at completely stopping the flow of blood into the sac, for it could not be expected to do so, as there is at least one collateral branch intervening, but it hopes that by diminishing the force and amount of blood flowing through the sac it will permit a contraction of the sac wall and encourage the formation of laminated clot within the sac in order that the aneurysm may become consolidated into firm fibrous tissue. It will thus be seen that it is by no means certain of curing the aneurysm, and though it is much easier to perform than Anel's operation, as we are dealing with normal tissues undisturbed by the sac, it is much more likely to lead to gangrene, for it requires the formation of a double collateral circulation, one at the site of ligature and the other round the aneurysm. This operation should not, therefore, be performed if gangrene is threatening, where much general arterial disease is present, where pressure over the main vessel does not diminish the circulation through the sac, or where it is feared that the sudden rise of blood pressure produced by the ligature of a main vessel might interfere with the action of the heart.

Two forms of distal ligature are also performed, but these are only practised for aneurysms where it is impossible to ligature the artery on the proximal side of the sac, in such cases as the commencement of the common carotid, the innominate, or the first part of the subclavian. These operations can hope only to arrest or diminish the flow of blood through the sac, and they are therefore likely to be less successful than proximal ligature.

(*c*) **Brasdor's Operation.** This was devised in 1760, and consists in tying the main vessel immediately beyond the sac, no branch intervening. This will cut off totally the circulation through the sac and do much to encourage consolidation.

(*d*) **Wardrop's operation** consists in ligaturing one or more, but not all, of the distal branches, where the main vessel divides beyond the sac. This operation, therefore, only diminishes and does not completely arrest the circulation through the sac, so that the chances of consolidation are considerably less than in the former operation. Its chief application will be to the case of innominate aneurysm, where either the subclavian or the common carotid may be ligatured.

In many cases after the ligature of a main vessel for aneurysm it will be found that a diminished pulsation persists or returns after one or two days. This is not necessarily an unfavourable sign, for it usually ceases again, and is probably due to the establishment of the collateral circulations. If, however, such a pulsation returns ten days or more after the operation, it is more unfavourable and more likely to persist. In this latter case it will require treatment, which should take the form of complete rest and elevation of the limb with compression of the vessel (see below); if this produces no improvement one of the other forms of operative interference described above will have to be tried.

(5) **Compression of the Vessel.** Compression of the sac itself or of the main vessel above the sac (occasionally below the sac) used to be employed to a considerable extent in the pre-antiseptic days. It is not often undertaken now, unless for some reason operation is totally out of the question.

Intermittent compression is applied by means of the finger (this will require relays of assistants), or by means of a tourniquet, clamp, weights, etc., for as long as the patient can tolerate it, which is not likely to be for more than half an hour on account of the pain produced. Although it is preferable, it is not essential that the flow of blood through the vessel should be completely arrested, and this should be done at intervals as often as possible. Continuous compression is performed under an anæsthetic by means of the fingers of relays of assistants, and this aims at completely obstructing the circulation for some hours. The assistant performing this will have to be relieved about every ten or fifteen minutes, as it is impossible to keep up the pressure for longer, although a weight resting upon the finger he employs will be found of assistance. Compression may occasionally be tried before operation, but it is not likely to succeed. If persisted in for some time it undoubtedly will encourage the formation of a collateral circulation, and this, though it renders the chances of gangrene considerably less, also may diminish the likelihood of a subsequent operation proving successful. Prolonged compression of this kind is by no means free from the risk of damaging the skin or other structures which are between it and the vessel. Direct pressure upon the sac itself may be produced in the case of aneurysms in the antecubital fossa or popliteal space by keeping the arm or leg flexed, but it can be applied only to small aneurysms.

(6) **The introduction of foreign material** into the sac in order to stimulate clotting is another method which has been employed without, however, meeting with very much success. It, therefore, should be employed only when any other form of operation is for some reason impossible, and it is most likely to succeed in the case of abdominal aneurysms. It is hoped that the presence of foreign material in the sac may encourage the process of clotting and consolidation of the aneurysm.

The **method of Moore and Corradi** consists in introducing into the aneurysm a hollow insulated needle of a very fine calibre, through which is inserted from 3 to 25 yards of very fine silver or steel wire. This wire introduced into the sac coils up and distributes itself to all parts of the aneurysm. Electrolysis is then performed through the wire, the negative pole being applied to the patient's skin elsewhere in the form of a plate, and the positive pole to the wire in the aneurysm. A galvanic current of from 20 to 100 milliamperes is allowed to flow for about an hour. The needle is then withdrawn, leaving the wire inside the aneurysm in the hope that clotting will be produced. A few brilliant successes in the case of innominate and abdominal aneurysms have been described by this method, but it is not free from risk, as sloughing and leakage of blood have sometimes followed it.

In other cases similar treatment has been employed without the electric current being used, and Colt has treated abdominal aneurysms in this way, introducing a fine gold wire, folded up into the form of a cage, which, when it is pushed down a hollow needle into the sac, expands automatically into an umbrella shape and provides a large wire surface in the sac for the blood to clot upon.

Acupuncture or needling was a method of treatment employed by Sir William Macewen and consists in passing one or more very sharp long needles into the aneurysmal sac at several points and inserting them till they just touch the opposite wall of the sac. They are left there for some hours, surrounded by sterile gauze, and are inserted at fresh spots from time to time, so that the pulsation and the blood movement will cause them to oscillate, in order that their points may scratch and scarify the lining of the sac. It is hoped that this will produce clotting and set up a plastic inflammation which will lead to thickening of the sac wall, and that when it has been repeated many times a slow consolidation of the aneurysm may be encouraged. Successes have also been recorded by this method, but it is by no means as promising in the case of an external aneurysm as are the usual operative methods.

Subcutaneous injections of gelatine have been employed in the hope that by this means clotting will be assisted. Three ounces of a 2 per cent. sterilised solution of gelatine are injected subcutaneously twice a week at body temperature, but it is very doubtful whether any good is likely to be done by this, and cases of tetanus and extensive thrombosis have followed the procedure.

(7) **Amputation of the limb** will be required in certain cases; *i.e.*, if other operative methods have failed and the aneurysm has recurred and is causing intolerable pain or threatening to rupture; when gangrene is imminent; if diffusion or suppuration has set in; in some cases of secondary hæmorrhage after operation; if the limb is completely useless; and in rare instances in order to diminish the flow

of blood through the sac. In the latter case the amputation is performed immediately below the aneurysm, but in all other instances it should be undertaken as short a distance above it as possible.

After any operation in which the sac is not excised, a swelling will persist and the patient should be warned of this. This swelling will, however, be much smaller than the original aneurysm and solid and non-pulsating.

TRAUMATIC ANEURYSMS

Inasmuch as a traumatic aneurysm is produced by some injury which divides all the coats of the arterial wall, it follows that the sac of such an aneurysm consists of the tissues round the artery fibrosed, thickened, and matted, the coats of the vessel wall themselves playing no part in the formation of the sac, while in most cases it will be found that these walls, unlike what obtains in the case of a pathological aneurysm, are perfectly healthy. The arterial injury producing this condition is nearly always an open wound and a wound of the punctured type with only a small external skin opening. Thus it is in the case of stab wounds and high velocity bullet wounds that the condition is most likely to be seen, while rarely it will be found to follow subcutaneous arterial injuries, such as rupture or laceration by fragments of bone. Such an aneurysm usually forms fairly rapidly after the injury, and in the course of twenty-four or forty-eight hours the pulsating swelling can be detected, though its size and shape will alter considerably as the surrounding tissues yield and thicken during the next week or two. It may continue slowly to increase in size, though after some time there often comes a stage when it becomes more or less stationary.

Much less commonly it will be found that a traumatic aneurysm does not appear till some weeks or months after the injury, this meaning that the original wound in the vessel wall had healed by a fibrous scar, which has subsequently become stretched and dilated into an aneurysmal sac.

A traumatic aneurysm is always of the sacculated type, while its subsequent course and the complications it is liable to are similar to those of the pathological aneurysms already described, as are also its clinical features, with the addition of a scar in the skin and a history of injury.

Those cases in which after an injury to a vessel a diffuse pulsating collection of blood forms in the cellular tissues without a definite sac wall are sometimes called diffuse traumatic aneurysms, but this is not a good name, and they are better regarded as **pulsating hæmatomata.**

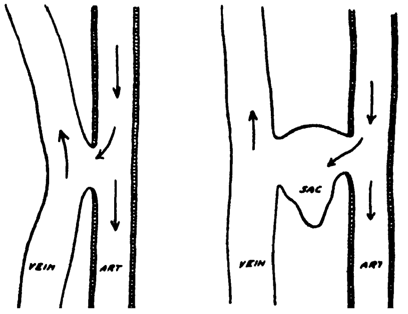
Treatment. The treatment of such an aneurysm is, in general, the same as that of the pathological type, but it must be remembered in this variety we are dealing with vessels whose walls are healthy and not diseased, while the condition is often found in healthy young adults. Thus the prognosis of operative treatment, especially if the suturing methods are employed, is very much better, and these measures, therefore, always should be undertaken if possible.

ARTERIOVENOUS ANEURYSMS

These may be regarded as a special variety of traumatic aneurysm, in which, *as the result of an injury, an abnormal communication has been made between an artery and a vein close to it.* This condition is, therefore, always associated with a history of an open wound of the punctured variety, and though it is occasionally due to a stab wound, it is much more commonly caused by the passage of a modern high velocity bullet. In former times the condition was especially common at the bend of the elbow, and due to a communication between the brachial artery and median basilic vein, as the result of enthusiastic attempts at bleeding. It is exceedingly doubtful whether this condition ever can arise spontaneously and without any injury. Two forms of the condition will be seen. In one the vein and artery communicate with each other through a sac which is between them or around them, and in the other their communication is direct without any sac intervening.

In all arteriovenous communications general changes in the heart are present, whether the actual communication is near the heart or in a distant vessel. There is a low diastolic pressure, an easily collapsing pulse, which is often unusually rapid, and at times capillary pulsation. The so-called " Bradycardiac reaction " is often present on closing or compressing the artery in which the communication is—namely, a marked slowing of the pulse rate even down to 30. This is abolished by the administration of atropin, and is probably a vagal effect. Cardiac enlargement is always present, and this may return to the normal size after a curative operation.

Aneurysmal Varix. In this case the communication is direct and there is no sac, and for this to occur it is, of course, necessary that the artery and vein concerned should be in contact with one another. The veins around become filled with arterial blood, and the vein concerned in the anastomosis, therefore, will become dilated for some distance, while it, together with its immediate tributaries, become thick-walled, tortuous, and pulsating, this pulsation and dilatation of the veins extending for some inches in all directions. Veins running in between muscles will become enormously distended with blood under high pressure, and may be a source of most dangerous hæmorrhage when any operation is performed. In addition to the pulsation of the veins around the lesion a marked and most peculiar thrill can be felt in and over them, similar to that which can be felt in the throat of a cat when it is purring. This thrill is continuous, but increases in magnitude at each beat of the heart. There also will be a loud murmur audible at the site of the lesion and for some inches proximal to it. This causes a loud whizzing or buzzing sound, which is also continuous and increases in loudness at each beat of the heart; it is sometimes called the " machinery murmur." The back pressure in the veins frequently leads to a certain amount of congestion and œdema of the whole limb, while in some instances the condition gives rise to an appearance resembling varicose veins (see also p. 284). Cardiac enlargement is always present.



Aneurysmal varix. Varicose aneurysm.

FIG. 160.

Treatment. The tendency of aneurysmal varices is to remain stationary, and in many cases in which they cause little inconvenience the only treatment required is the application of an elastic bandage to support them. Occasionally, however, they progress, while the patient will complain of pain or especially of the inconvenience caused by the buzzing noise, and then operation will have to be undertaken. As a preliminary, means must be taken (such as intermittent compression) to encourage the formation of a collateral circulation, and then the artery and vein should be explored, the main vessel being first temporarily controlled above. The ideal treatment is to separate the artery and vein, and suture the opening in each, but this is often difficult. If this fails the artery should be ligatured above and below the communication with the vein. It is better not to interfere with the vein if possible, but in many cases this will be found to be so distended that until it is removed the artery cannot be reached. In the case of a young and healthy limb, and especially in one where there have been some chances of a previous collateral circulation forming, the risk of gangrene on tying the main vessel is in no way increased (possibly diminished) by simultaneous ligature of the accompanying vein.

Varicose aneurysm is the name given to the other condition in which the vein and artery communicate *via* a sac which intervenes between them or surrounds them, this sac being, of course, of the false type with walls only formed of fibrous tissue. This variety possibly sometimes supervenes upon what was, in the first instance, a simple traumatic aneurysm, which has become adherent to a neighbouring vein and has actually opened into it, but this must be very rare. The signs and symptoms are similar to the preceding, except that in this case the thrill and the venous dilatation are usually less marked, and we have, in addition, the presence at the site of the lesion of a pulsating swelling. In many instances it is difficult before operation to say with which type we are dealing.

Treatment. The tendency of the varicose aneurysm is to increase and spread, even to rupture, whilst spontaneous cure is most unlikely, and thus its treatment differs from the preceding condition in that operation should always be undertaken. The artery and vein should be exposed, and, if possible, the sac excised and the openings into both vessels sutured. This is often difficult, and if it cannot be done an almost equally good result will be obtained by tying both the artery and the vein immediately above and below the point where they communicate with the sac, and then excising the sac and the injured section of artery and vein. If this in its turn is impossible, the artery should be tied immediately above and below the communication. Ligature of the artery above the communication only probably will not lead to cure, as the blood will re-enter the sac from the distal end of the artery, while tying the artery below the communication only is absolutely inefficient and very likely to lead to gangrene.

Orbital Aneurysms. The condition of **pulsating exophthalmos**, in which one or both eyes are prominent and can be seen and felt to pulsate, is occasionally met with, and it is usually an indication of the presence of an aneurysm in or behind the orbit. The causes of this condition are either an aneurysm of the ophthalmic or internal carotid artery, a cirsoid aneurysm, or deeply seated cavernous angioma, a thrombosis of the cavernous sinus (in which case the pulsation is very slight), or (the most common condition of all) an *aneurysmal varix between the internal carotid and the cavernous sinus.* If due to the last cause the condition is traumatic, and follows either a penetrating wound or, more commonly, a blow on the head, the cheek or the lower jaw, which has caused a fractured base of the skull. We have seen more cases following the kick of a horse on the face than any other injury. In the case of an arteriovenous communication, in addition to the pulsating exophthalmos, there will be congestion and œdema of the eyelids, while the veins are prominent and may pulsate. The conjunctival vessels are also engorged, while the movements of the eyeball will be much limited, with an accompanying diminution of vision; at times a thrill can be felt. In some cases the condition leads to opacity and ulceration of the cornea. The patient complains of pain and tension in the orbit and of a continuous rushing or roaring sound, this continuous "machinery" bruit being heard with the stethoscope all over the forehead and temporal region, but it is especially loud when the stethoscope is placed over the root of the nose or the lower part of the frontal sinus. Vascular sarcomata of the orbital wall often may resemble this condition, but here the proptosis will be more marked, the pulsation and bruit less, and a swelling usually can be palpated behind the eyeball. The condition is usually progressive, and leads slowly to total ophthalmoplegia and blindness due to optic atrophy.

Treatment. Experimental compression of first one and then the other common carotid must be made to see which side produces most mitigation of the noise and other symptoms. The internal carotid should then be tied on whichever side appears to produce most effect. It should be remembered that ligature of the common carotid is most unlikely to be successful unless accompanied by ligature of the external carotid also, for the reason given on p. 278.

Aneurysm by Anastomosis (Plexiform Angioma). This is a rare vascular tumour met with in the neck, scalp, and occasionally on the hand and forearm, when it may be accompanied by considerable lack of nutrition, coldness, blueness, etc. It is composed of arteries, veins, and capillaries, and consists of several distinct cord-like pulsating swellings with a loud bruit and marked thrill. It usually slowly increases in size, and may give rise to ulceration and hæmorrhage. The condition is sometimes seen inside the cancellous tissue of the bones, and then resembles a sarcoma, while occasionally it is congenital and the vessels are large enough to constitute an arteriovenous communication.

Treatment. This resembles that of a nævus (see p. 207), and consists in electrolysis, etc. Ligature of the main vessels is sometimes successful, but often fails on account of the free anastomoses and number of branches involved.

Cirsoid Aneurysm (Arterial Angioma). This is a tumour due to enlarged arterial branches with a plexiform and tortuous arrangement; it does not contain veins and capillaries like the above condition, and usually arises in the temporal or other scalp arteries. Though in some cases it is congenital, more commonly it appears to follow upon an injury; it is usually seen in adolescent males, in whom the vessels increase slowly in size and become tortuous and dilated; they sometimes lie in grooves in the bone. It gives rise to a soft, compressible, pulsating tumour, in which separate cord-like swellings may be felt; a thrill is often present, while there is a constant loud roaring bruit, which the patient can hear and which may worry him much. The condition does not often rupture or ulcerate, but if it does hæmorrhage is profuse. It slowly increases in size, and ultimately may involve half the scalp and become pendulous (see Chapter II., Vol. II.).

Treatment. Electrolysis and similar methods may be tried, but usually fail. Excision should then be attempted, but the hæmorrhage will be formidable unless an elastic tourniquet round the scalp or ligature of the main vessels is employed.

ANEURYSMS OF SPECIAL ARTERIES

For a further account of aneurysms and an account of all aneurysms of special arteries, see Appendix.

INJURIES OF VEINS

Subcutaneous Rupture. This is not uncommon, and will be seen in the popliteal, the axillary and the femoral veins often in association with a dislocation or a fracture; veins which are varicose not infrequently rupture. There is much less tendency for the walls of the vessel to contract and retract than in the case of an artery, but the blood pressure being very much lower, there will be far less bleeding, and the pressure of the extravasated blood usually automatically arrests the hæmorrhage before it has gone very far. The swelling formed by the extravasated blood does not of course pulsate, though if the rupture has occurred in the main vein of a limb there may be considerable congestion and œdema of the parts beyond; the pulse, of course, will be unaffected. In the way of treatment the condition usually only requires complete rest, with the limb elevated for a week and a firm supporting bandage. Operation for ligature of the vein is hardly ever required, while the risks of gangrene or suppuration are very slight, and of aneurysm formation nil.

Post-traumatic Thrombosis occurs not infrequently in the legs and occasionally in the veins, especially in the region of the axilla.

Wounds. Wounds of large veins are not uncommon, and are seen as the result of accidents, stabs or injuries, and also during the course of operations. The veins have walls which are so thin that they usually collapse easily. Hæmorrhage from a damaged vein is profuse, dark blood welling up continuously, but it is very easily controlled by light pressure on the bleeding spot. Some veins will bleed from either end, and during operations hæmorrhage from veins may be far more troublesome than from arteries, as in addition to causing the patient loss of blood, it interferes considerably with the clearness of vision in the operation wound. If the bleeding comes from a lateral opening or a puncture in a vein, it can be arrested by a lateral ligature, by suturing the opening so as not to block the lumen completely, by the application of a Cushing's silver clip, or in many cases by pressure with a pad of gauze or by plugging. In other cases it will be necessary to ligature the vein, but this should be avoided if possible in the case of the main vein of a limb, as it is liable to lead to subsequent œdema of the parts beyond.

When veins are encountered running in bony canals, as in the skull, hæmorrhage from them can be controlled either by crushing the bone in upon them or by a plug of bone wax. If a vein is wounded at or near a point where it passes through a firm layer of fascia, hæmorrhage will be far more profuse, as the fascia probably will hold the mouth of the vein open and prevent it from collapsing.

Air Embolism. This is an uncommon condition due to the entry of air into a large vein, which has been cut or opened in the case of a cut throat or during an operation, and thus it is most likely to occur in operations on the root of the neck, the chest, axilla or groin. In these situations when a large vein is opened, if its walls are rigid, adherent to surrounding tissues or being dragged upon, they will not collapse, so that the wound remains patent, and then inspiratory suction and the negative pressure which it creates within the big veins will be sufficient to draw air into the vein and pass it on to the heart. When this occurs a sharp hissing sound is heard and the blood in the depths of the wound may become frothy. On some occasions this occurs without any evil results, but in others the patient collapses within a few seconds and becomes pale or cyanosed with dilated pupils. The pulse becomes weak and running, while the heart continues to beat forcibly, but irregularly and tumultuously, and on listening to the heart sounds, gurgling, bubbling or wheezing noises will be heard. In most cases the patient slowly recovers, but death sometimes follows rapidly. The risk of this condition should be remembered when operating upon any area where a large vein is liable to be cut or torn. Though known by the name of "air embolism," it is very doubtful whether embolism has anything to do with this condition, which is probably due to interference with the heart's action by air bubbles in the blood inside it; if the heart muscle has nothing except froth to contract upon, it ceases to function properly.

Treatment. Directly it is recognised that a vein has been opened, and especially if the hissing noise is heard, the finger should be placed upon the vein proximal to the wound in it, and the operation wound should be kept filled with blood or warm saline until the opening in the vessel is secured. If the patient shows signs of collapse the head must be lowered, the heart's action stimulated and steadied by injections of camphor, strychnine or digitalin. It seems scarcely necessary to draw attention to the futility of the practice, which is not infrequent, of injecting 15 or 20 minims of ether as a stimulant into a patient who has already received, it may be, half a pint or more in the course of his anæsthetic.

If these measures fail, stretching the anal sphincter and cardiac massage through an abdominal incision must be tried. Artificial respiration is not usually necessary, as the condition is essentially a cardiac and not a respiratory failure, being due as far as is known to the blood in the heart being full of froth and air bubbles, so that the heart has no fluid to contract upon. This being so, aspiration of the left ventricle of the heart with a syringe and needle has been advised to suck out the frothing and bubbling blood.

DISEASES OF VEINS

Venous Thrombosis. Thrombosis has been described on p. 260, and it must be remembered that it is far more common in veins than in arteries, because the blood stream is slower and the vessel walls more vulnerable. Venous thrombosis is sometimes due to bruising or damage of the vein wall or to general diseases such as gout, syphilis and typhoid, in which cases no infective element is present in the vein wall and clot; but by far the most common cause of the condition is a bacterial inflammation of the wall of the vein known as Phlebitis.

Phlebitis, or Thrombophlebitis. This condition, which is common, is due to inflammation of the wall of a vein, and is usually seen in two slightly different forms:—

(*a*) The commonest form, which may be known as **simple phlebitis,** is a localised inflammation of the vein wall either from an injury or due to an infection of low virulence which leads to thrombosis and blocking of the lumen; this will spread a short distance up and down the vessel, but the thrombus does not become infected, and there is little or no tendency for pieces of it to soften and break loose. This condition may arise from an injury to the vessel wall, after muscular strain, or from the continued pressure or irritation of a tumour, while it is specially liable to occur in varicose veins (where it is often induced by injection) and in the leg in patients who are weak and anæmic or who have been long in bed. Thus it is not infrequently seen as a complication of fractures, of childbirth, and of the more serious abdominal operations.

It is especially likely to occur if an infection of any kind is present in the patient's system.

Primary thrombosis of the axillary vein is occasionally seen as the result of some slight injury or in patients who have been doing heavy manual work. A similar condition is occasionally seen in the thoraco-epigastric vein. Both these conditions give rise to pain, tenderness and to a tough, hard cord along the line of the vein concerned, with some œdema below it.

(*b*) The other and more serious type may be known as an **infective phlebitis**, and in this case the infection is more virulent, the vessel walls soften and the thrombus is invaded by micro-organisms, so that it also softens, tends to break up and give rise to multiple infective emboli. This form will occur only when a virulent infection is present in some part of the patient's system and usually arises as an inflammation outside and around a vein (Periphlebitis), produced by such a condition as a septic wound, an acute osteitis of a bone, or a suppurative mastoid infection, which spreads to the wall of the lateral sinus. It may supervene sometimes as a complication in the previous simpler form. In addition to the lateral sinus, infective thrombosis is occasionally seen in the inferior vena cava as the result of an extension of infection from a tributary vein. This infective form of the disease is especially liable to give rise to infective emboli (see p. 261) and pyæmia.

The wall of a vein which is involved in a phlebitis, whether simple or infective, is congested and thickened, while the endothelial lining is reddened and roughened. It will contain a thrombus of the red variety, which may become organised. If it is infected, however, the clot becomes soft and breaks down to form a dirty-looking pus, while a localised abscess will form, within the vein first of all, but ultimately, when the vessel wall has given way, the suppuration will extend for some distance into the tissues round.

Embolism is much less common in the simple form, but if it does occur it will probably be a much larger embolus than the small infected emboli which occur in infective phlebitis. Its immediate effects, therefore, may be more serious.

Clinical Features : (a) Simple Phlebitis. This disease is most frequently seen in the leg, in veins which are varicose (see p. 287), and in those of the internal saphenous system ; the onset of the condition is sudden, with a sharp localised pain and a rise in temperature of one or two degrees, sometimes accompanied by shivering and malaise. If the vein affected is a superficial one, soon there will appear swelling and tenderness along its course, the swollen vein being felt as a tender cord, with localised enlargements corresponding to valves or pouches. In a few hours the skin over the vein becomes red, dusky and congested, while the swelling will spread and be accompanied by an area of œdema for a short distance round. The limb feels stiff and uncomfortable, and there always will be a certain amount of œdema distal to the lesion, in the parts drained by the vein ; this will be, however, often very slight in the case of a superficial vein as the collateral circulation is so free. The pain and fever will pass off in a few days, but the swelling, redness, tenderness and œdema will last for some weeks, and if suppuration sets in, as is not at all infrequent, the signs of a localised, subacute abscess will appear.

If one of the deep and main veins is involved, such as the iliac, axillary, femoral or popliteal, the local pain, tenderness and swelling will be less marked, on account of the depth of the vein, but there will be great œdema of the whole limb below. This will become firm and boggy, white in colour, with marked pitting on pressure. Here again the pain will last only a few days, but the œdema will persist for weeks. This variety is seen in its most characteristic form in the femoral vein of puerperal women, when it is known as **phlegmasia alba dolens.** It also occurs after abdominal operations. Usually the vein ultimately becomes patent again from canalisation or absorption of the clot, but this takes many weeks. The left leg is most commonly affected.

Treatment. Where one or more superficial veins are involved, especially if as a result of trauma, the condition need not be regarded seriously, and after a day or so of rest to relieve pain, by keeping the limb elevated and at rest, normal use may be resumed. If, however, deep veins are involved, or an infective origin is suspected for the phlebitis, the condition always must be regarded as a serious one, and the first essential in treatment is to place the limb absolutely at rest. Thus the patient must go to bed, with the foot of the bed raised eight or ten inches and the leg immobilised by sandbags. The limb must be moved and handled as little as possible in order that the clot may not be shifted and give rise to an embolus : the elevation also assists the venous return and lessens the œdema. In addition to this, local applications to the tender part must be made, though the limb must not be disturbed in any way when the dressing is done. The limb may be painted with glycerine and belladonna, lead and opium lotion or ichthyol ointment, while hot fomentations are sometimes comforting ; it should be surrounded with thick layers of cotton wool to keep it warm. Intravenous injections of 0·5 per cent. solution of sodium citrate in normal saline (about 5 ounces) have been advocated to relieve the pain and hasten the process of organisation, but we have no experience of this. Stimulants should be avoided and the diet must be as nutritious as possible.

As soon as the danger of embolism is over, and it is thought that the clot has either absorbed or become organised, massage and douches should be employed and movements of the limb encouraged. This must never be thought of for at least three weeks or until all signs of redness and inflammation have disappeared, and in most cases four or five weeks is a safer period to wait. When the patient first begins to walk he should wear an elastic bandage to support his veins. Should an abscess form at the site of the thrombosis, it must be incised and drained in the ordinary way. If the clot appears to be spreading slowly up the vein, it will be wise to ligature the vessel a short distance above it.

(*b*) *Infective Phlebitis.* In the case of an infective phlebitis the onset is even more sudden and fever and rigors will be marked. If the vein involved is one which is palpable, the local inflammatory process will be much more acute and spread more rapidly, but if, as is more commonly the case, the vessel affected is an internal one or is the lateral sinus, these local signs will not be noted and the condition will have to be inferred from the repeated rigors and signs of severe general infection (pyæmia) which are associated with it. In many cases where peripheral veins are affected this condition will not be recognisable separately, as it will be masked by the severity of the general infection which may be either its cause or effect.

Treatment. The treatment of this condition is in general the same as that of simple phlebitis, but here suppuration is almost certain to set in and multiple incisions will be needed. In addition to this the condition which has caused the infective phlebitis will also need energetic treatment. The pyæmic symptoms which are nearly always present often can be controlled by ligaturing the vein, both on the distal and the proximal side of the clot. This should be done where a single vein is involved, and the internal jugular vein is often tied with great success in the cases where the lateral sinus is involved, and thus the infective emboli may have their approach to the general circulation cut off. If more than one vein in the limb is involved this is not feasible, and then the question of amputation may have to be considered.

FIG. 161. Infective phlebitis of internal saphena vein.

VARICOSE VEINS (VARIX)

A varicose vein is a vein which, from changes in its walls and increased pressure within it, has become permanently dilated and lengthened, so that it will also be tortuous. This condition may affect large groups of veins throughout almost the whole course of their length or in other cases appears to be confined to one or two localised spots in the course of a vein. Though any vein in the body may become varicose, the condition is hardly ever seen except round the œsophageal opening of the stomach, in the spermatic cord (varicocele, see Vol. II., Chapter XXI.), round the anus (hæmorrhoids, see Vol. II., Chapter XIX.), and in the leg, and this last is the type of varix that we shall consider now.

It is highly probable that the main cause of varicose veins lies in a congenital weakness in the valves of the veins affected, which is accompanied by a congenital change in their walls, tending to weaken them. In addition to being weak the valves may be irregularly arranged or few in number. That there is a congenital tendency seems probable from the fact that the condition is specially common in adolescence, that in many cases it is hereditary, while it is sometimes the same portion of the same vein which is found to be involved in different members or generations of the same family. In addition to this, any condition which leads to intermittent distension of the vein or increased pressure within it will play an important part in precipitating the onset of the disease. Thus diseases of the heart, liver or lungs, which give rise to back pressure, or the pressure of a rapidly growing abdominal tumour or pregnant uterus upon the veins, often play an important part in producing the condition in veins which are congenitally weak. Prolonged standing, continual violent exertion and muscular effort (as seen in athletes), and the wearing of tight garters are also important agents, and indeed it is probable that in some cases one violent muscular effort may rupture certain of the valves in the veins and thus cause the condition to start. The disease is seen especially in athletes, people who do much standing and pregnant women. Once dilatation has started and valvular incompetence has set in, the increasing pressure of the unsupported column of blood in the legs will cause it to progress steadily.

Thrombosis of the main deep veins of the leg will throw an increased amount of work upon the superficial veins, and this will cause them in many cases to become dilated and varicose, although the condition is really a compensatory hypertrophy. This is especially seen after typhoid fever in connection with thrombosis of the femoral vein or inferior vena cava. If such a thrombus is absorbed the venous dilatation may disappear, but more commonly it becomes permanent. A similar condition is also seen in connection with an arteriovenous aneurysm (see p. 276).

Morbid Anatomy. The French school of surgery showed many years ago that the deep intramuscular veins, especially those in the soleus, are the primary seat of the varicosity, and that the superficial veins only enlarge secondarily to the failure of the valves of these deep veins. It follows, therefore, that the superficial varices tend to appear first at those points where communicating veins exist between the superficial and deep veins. Such communications exist mainly at certain points of the internal saphena, at the junction with the femoral and at points approximately one-third and two-thirds of the course down the thigh, and similar points on the leg; with the external saphena these points are far more numerous. It is common knowledge that it is at these points that the superficial varices first appear, and that here develop the large knots of turgid veins in later cases. The condition most commonly affects the internal saphenous system of the leg, and often spreads to the other veins also. The valves being deficient, they cannot support the column of blood above them properly, and thus the pressure in the veins below is permanently increased. Usually it is only certain segments of the vein which are affected, and being lengthened as well as dilated, the affected portions become tortuous, while their coils are often found to be bound together by strands of fibrous tissue. The walls are thickened, so that if the vein is cut across it remains open and gapes, and in addition to being thickened the vein walls are very brittle. Microscopically it will be found that the tunica intima is little changed, but that the tunica media loses its muscle fibres and becomes converted into pure fibrous tissue. The walls are only thickened irregularly, with the result that in places thin-walled pouches project from the vein and form cyst-like dilatations. The skin over these dilatations is usually thinned, atrophic and adherent to the vein underneath, so that not only is the swelling very obvious, but it is especially liable to rupture or thrombosis. Occasionally a single pouch of this kind becomes very large and obvious. This is specially seen over the saphenous opening, where a swelling as big as a hen's egg may form and give rise to difficulties in diagnosis, for it may closely resemble a femoral hernia or psoas abscess. Such a condition is known as a **saphenous varix.**

Clinical Features. Varicose veins are equally common in either leg and in either sex (with the exception of the special liability in the case of pregnant women), and usually appear for the first time under the age of thirty. The dilated and twisted veins can be seen easily and felt when the patient is standing up. They most commonly involve the internal saphenous system, but will be found to vary greatly in extent, as sometimes almost all the superficial veins of both legs are implicated, while in other instances they appear to be confined to just a few inches of one particular vein. Pouches and bead-like swellings, which stand out even more prominently, are common, while when the dilated vessels are palpated they feel tough and firm as the result of periphlebitis. Hard, nodular swellings may be present at places which are due to old thrombi or to calcification. The skin over the veins is atrophied and thinned, so that their bluish colour can be seen, while if the limb happens to be œdematous the veins will no longer be visible but on palpation will feel like soft gutters running up and down the firm limb. In places the veins may be so tortuous that they resemble large clusters of dilated vessels. In the big vessels and in a saphenous varix, if present, there will be a marked impulse and thrill on coughing, this impulse not usually being detectable below the knee. The veins may be arranged in a most complex manner, and though the most marked dilatation is nearly always on the inner side of the limb, large transverse branches are often found running across the back or front of the leg below the knee to communicate with those on the outer side. Around the ankle and on the foot the vessels are commonly very much smaller and appear as thin blue radiating streaks.

FIG. 162. Varicose veins at the inner side of the knee, with marked tortuosity and pouching.

When the patient is laid flat and the leg elevated, the veins will empty and disappear. If, then, pressure is made over the saphenous opening and the patient stands up while the pressure is maintained, the veins will fill only very slowly from below, provided the internal saphenous system alone is involved. If the external saphenous system is also implicated, and has big communications with the internal one, the veins will fill considerably more quickly from below, while when the pressure over the saphenous opening is relieved, the blood can be seen to rush down from above and fill the veins. This is known as *Trendelenburg's Test.*

The symptoms produced by varicose veins vary greatly and bear little relation to the number or size of the veins. The most common complaint is of aching and a sense of fulness in the limb after standing or walking. The pain is sometimes quite severe, and patients also will complain occasionally of muscular cramps. These symptoms are relieved at once by lying down and raising the limb. When the whole length of the internal saphenous system of veins is involved there is generally far more discomfort than in those cases where the thigh veins are unaffected and only those below the knee are diseased, for in the former case the pressure in the veins, which is responsible for the discomfort, is much higher. After exercise or standing there is frequently a certain amount of œdema of the feet.

Complications. When the condition has been present for some time the skin capillaries become dilated and appear as small red spots which later run together and give rise in the lower part of the leg to large patches of a mahogany-brown colour, this pigmentation being due to the deposit of blood pigment in the tissues, while it is frequently the precursor of one or other of the two next complications.

Varicose eczema (or better, varicose dermatitis) is a frequent sequel, and is due to faulty nutrition of the skin caused by the stagnation of blood, while the presence of dirt, assisted by the irritation of rough clothing, helps to produce this condition. It must be remembered that as the pressure in the veins rises owing to their varicosity, it becomes almost equal to that in the arterioles, so that the circulation in the skin will be greatly impeded.

Varicose Ulcer. This may occur in any case of varicose veins, and is especially common when pigmentation or dermatitis is present. It is often precipitated by a minor injury, such as a scratch or abrasion. For a description of this form of ulcer, see p. 147.

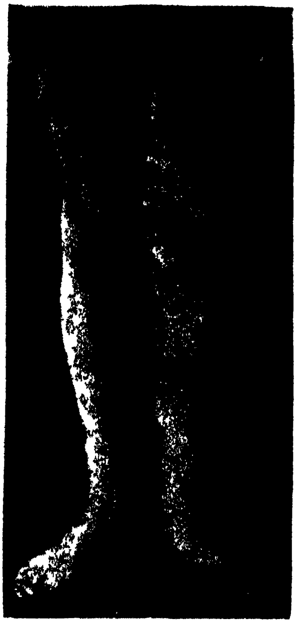


FIG. 163. Extensive varicose veins affecting chiefly the internal aspect of the left leg.

Phlebitis and thrombosis are common in varicose veins. This condition is usually found in the dilatations or pouches or at acute bends in the vessels, and is especially liable to follow a minor injury. The condition has the characteristics of a thrombo-phlebitis described on p. 281, and in a few cases proves dangerous by spreading into the main veins, by giving rise to emboli or by becoming infected. The larger the vein thrombosed, the more serious is the condition. In some cases, especially in elderly people, the thrombus becomes organised and cures the condition by obliterating the vein. When this has occurred, sometimes calcification will commence and give rise to a phlebolith.

Hæmorrhage sometimes occurs from a varicose vein as the result of its rupturing, either spontaneously, from a slight injury, or as the result of ulceration. The bleeding is furious and copious, and inasmuch as the valves are incompetent, occurs from both ends of the vein ; in fact, the upper end of the vein may be regarded as a column of blood extending directly up to the right auricle. This form of hæmorrhage is not infrequently fatal, especially in intoxicated people when no help is at hand. It can be stopped at once by elevation of the limb and by applying pressure with a bandage over the bleeding point.

Treatment. The treatment may be either palliative, by injection or by operation. Should injection be contra-indicated by the presence of only superficial blue cuticular varices, or by the patient's general condition, or the presence of deep thrombosis, palliative treatment must be adopted. It is furthermore important to realise that even after injection the leg needs care and protection and that even then some 30 per cent. of cases develop further varices in the course of five years.

Palliative Treatment. If there is a cardiac or pulmonary cause, this should be treated, while any source of obstruction to the venous return, in the form of tight garters, pelvic tumours, persistent constipation, etc., should be removed. Prolonged standing and walking and severe muscular exercise must be forbidden, while rest with the limb elevated at intervals during the day is beneficial. The veins must be supported and prevented from ever becoming distended by means either of an elastic bandage (crêpe velpeau or indiarubber), or better still, by silk or rubber elastic stockings, which must be carefully fitted. These appliances must be put on in the morning before the patient gets up and not removed at night until after he lies down. Bandages must be put on the limb from below upwards. If rubber bandages or elastic stockings are used, care must be taken to keep the limb clean and well powdered, or the skin will become irritated and sore. In cases of deep thrombosis, and superficial cuticular varices, and where healed ulcers are present, it is also wise to use a support of this nature, while in the case of old ulcers the occasional (six monthly) application of an elastoplast or varicosan bandage, or an Unna's dressing for a fortnight will do much to prevent subsequent breaking down of the lesion.

Injection Treatment. This consists in the obliteration of groups and lengths of the veins by injecting into them substances which produce a rapid and aseptic thrombosis, a process much more easy to produce in varicose than in normal veins. By each injection several inches of vein can be obliterated, and in cases which are not very extensive a course of several injections will produce very great benefit.

There appears to be very small risk of embolism so long as the resulting thrombus remains sterile, but it is an additional safeguard if the injection be made with the patient sitting up and the leg straight out or hanging down, according to which position enables the vein to be visible, as when the leg is erect the blood in a varicose vein flows toward the periphery.

Many solutions have been used for injection, all of which will effect a cure provided the fluid is injected *into* the vein and none escapes into the tissues around, an accident often resulting in sloughing of the tissues and ulceration.

The following solutions can be used ; all must, of course, be *sterile* :—

Sodium salicylate, 20 to 40 per cent., 1 to 3 c.c. an injection ; sodium morrhuate, 5 per cent., 5 c.c. ; sodium chloride, 20 per cent., 3 to 10 c.c. ; grape sugar, 50 per cent., 5 c.c. ; perchloride of mercury, 1 or 2 per cent., 1 to 3 c.c. (see also *Lancet*, January 29th, 1927) ; quinine hydrochloride, 5 per cent. c̄ urethane, 2½ per cent. in saline, 5 to 15 c.c. ; or 9 per cent. quinine, c̄ 4½ per cent. urethane, 1 to 5 c.c.

Of these we unhesitatingly, and after considerable experience, recommended the quinine and urethane, usually 5 per cent. solution with 5 c.c. as the initial injection, the 9 per cent. solution being given in those rare cases where 5 per cent. solution fails to produce thrombosis. The injection is quite painless, though some stiffness and discoloration occur locally in twenty-four hours, and the general effects are slight and transitory ; the reaction continues locally for about ten days, and no second injection should be given *anywhere* until all tenderness on palpation has gone from the thrombosed area, usually fourteen days after first injection.

It is impossible to give a prognosis as to the results, some patients having the entire leg cured by one injection and others clotting only for an inch or so ; some veins clot completely and in others a small central canal persists with a thickened wall, so that the vein no longer bulges or shows.

Certain cases are unsuitable for injection :—

(1) Deep femoral thrombosis, white leg, etc.
(2) Acute phlebitis, as often follows injury.
(3) Pregnancy, as other veins occur and there may be a risk of abortion.

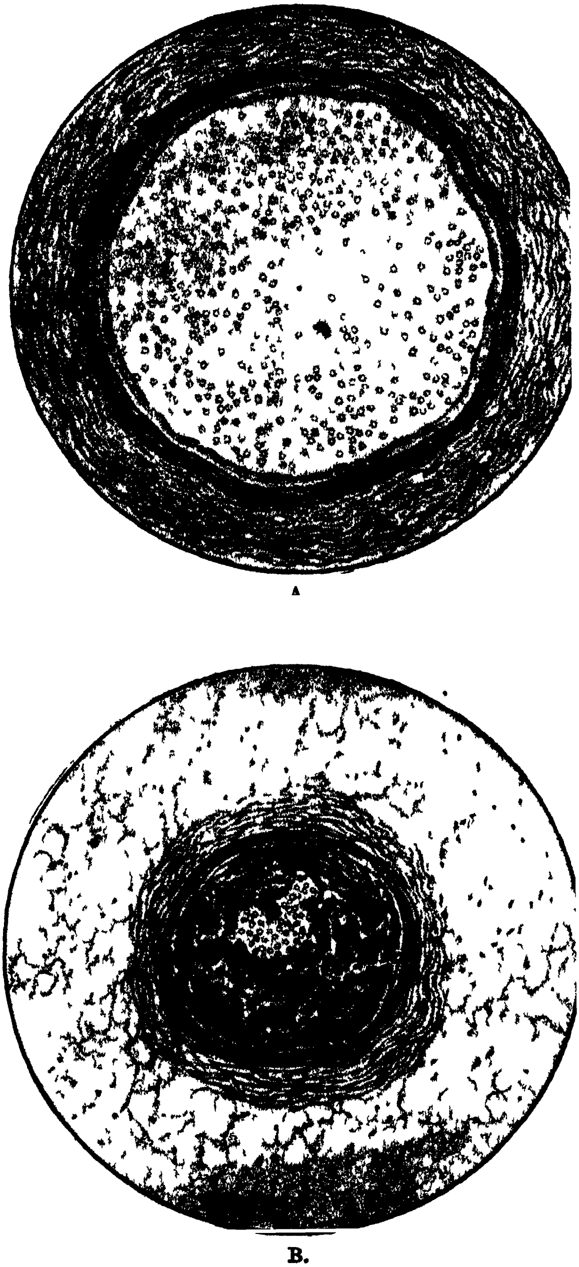


FIG. 164. Diagrammatic section of varicose veins. A. Before. B. Ten days after injection with quinine hydrochloride 5 per cent., showing shrinkage of lumen, and organising clot with small central canal still persisting.

(4) The presence of a Trendelenburg back impulse on coughing; such cases *never* clot unless Trendelenburg's operation for the ligature of the saphenous vein is first carried out.

Technique for Injection. The patient sits with the leg either straight out or dependent so that the vein just shows. The leg is then cleaned with 2 per cent. iodine in spirit.

The injection in all cases should be made from above downwards, starting with the highest group of veins and 5 c.c. of quinine solution injected; this ensures a more extensive obliteration. A sponge is held over the puncture, and a piece of zinc oxide strapping applied, or if the veins are large they should be bandaged to prevent a mass of clotted veins forming. The patient can then walk away and pursue his usual avocation.

Whenever there is a thrill or impulse on coughing, and especially when the varicose veins are confined to the internal saphenous system and are causing pain from back pressure, **Trendelenburg's operation** should be practised, and this is essential as a preliminary to cure of the veins by injection in all cases where such a cough thrill is present. This consists in ligaturing the internal saphenous vein and removing a portion of it as high up as possible, and it is best to excise completely the saphenous pouch and the branches which enter it. By this means the back pressure from the big veins of the trunk is cut off. An incision two inches long should be made a finger's breadth internal to the femoral pulse over the saphenous opening and running downwards and outwards. Through this the vein and its branches are isolated, tied in two places and portions of them removed. It will usually be found that there are four separate branches entering the saphenous pouch. Injection of the veins below can be carried out at the time of operation and subsequently during the patient's convalescence.

Operative Treatment. This is now seldom necessary, save Trendelenburg's operation as mentioned above, which in itself seldom cures the veins, but relieves pain from the distended veins.

Excision of groups of veins may have to be performed in some cases, usually at the points where anastomosis occurs between the superficial and deep veins, as collateral circulation is occasionally established here after ligation at the saphena opening, and a cough impulse returns. As a routine treatment, local excisions are no longer performed, and such old-fashioned methods as those by which long lengths of the veins were dragged out through a small incision with the aid of a long enucleator, such as Babcock's Acorn stylet, should never be practised.

OPERATIONS UPON THE BLOOD VESSELS

The operations performed upon the blood vessels consist of suture of arteries, certain suturing operations performed upon aneurysms and known as aneurysmorrhaphy, ligature of the main arteries, venesection, etc.

Suture of Arteries. In suturing arteries or in the suturing operations performed upon aneurysms special needles and materials must be used. These consist of very small and very fine needles, round-bodied and either straight or curved, which may be held in specially devised small needle-holders. The suture material consists of a special very fine silk or linen thread which should be run through sterilised vaseline before use, while special small spring clamps are employed temporarily to control the blood flowing in the vessels. Until these clamps can be placed in position during the operation, a tourniquet is essential.

Wounds in the large arteries may be sutured if they are straight and clean cut, while if the vessel is completely divided, end-to-end suture is possible. In both these cases blood will continue to flow past the wound and the circulation will be maintained for a time at any rate, though it is probable that in many cases after a few hours or days thrombosis sets in and the vessel becomes blocked. Vessels should never be sutured in the presence of sepsis or if the wounds in them are jagged or irregular. A tourniquet must be employed to control the circulation, the hæmatoma round the wound is opened up and completely turned out, when the vessel and the wound in it may be easily exposed for some little distance, controlling clamps applied above and below the wound, and the tourniquet removed. If thought suitable for suture, a method must be employed which ensures that no roughened wound edges and no part of the suture material project into the lumen of the vessel, or thrombosis and embolism will occur. If the wound is irregular it should be carefully trimmed, its edges rubbed over with sterile vaseline and the special silk sutures introduced in mattress form, care being taken to evert the edges of the wound. The stitches should not pass through the intima. Two layers of stitches should be applied, the superficial layer invaginating the deep layer. In addition to being employed in the case of accidental wounds or division of the larger arteries, the various methods of arterial suture are also used to close incisions in vessels made by the surgeon to extract emboli, etc., in anastomosing vessels or in reversing the arterial and venous circulation in a limb which is suffering from impending gangrene.

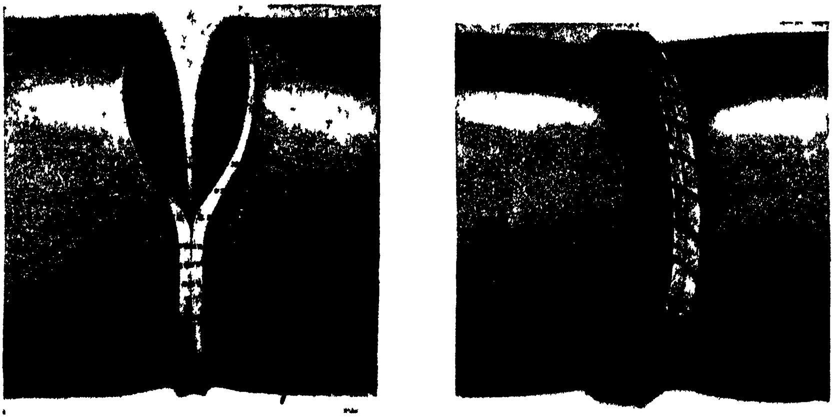


FIG. 165. Dorrance's method of end-to-end anastomosis of vessels.

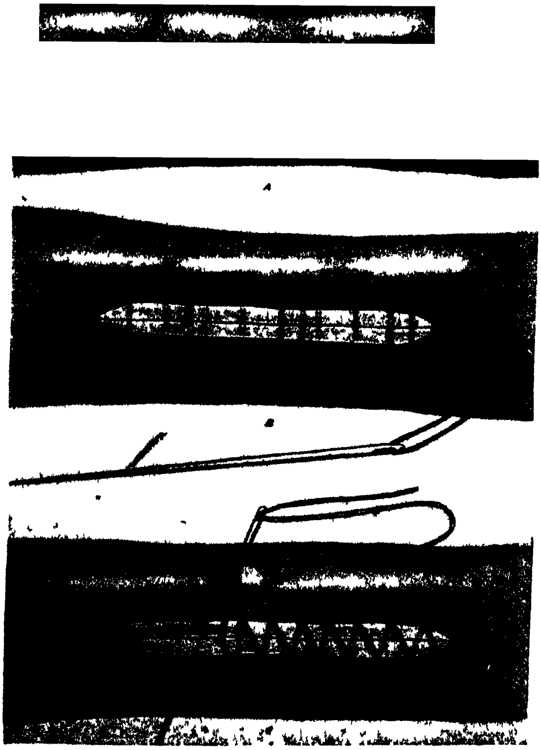


FIG. 166. Dorrance's method of suture of a longitudinal wound of an artery.

If the wound in the vessel is an irregular tear or if the artery is cut clean across, ligature of both ends may be the only treatment, but in other cases, by trimming the two ends and resecting the damaged portion, it is possible to perform end-to-end anastomosis of the vessels. The details of the suturing both in this operation and in lateral arterial suture are given in Fig. 160 and Fig. 161. It is of the greatest importance in end-to-end anastomosis that there should be no tension on the suture line. Even if thrombosis follows these proceedings the circulation will be maintained for a few hours at least. Recently heparin has been used in these cases and may in the future improve the results. After the suturing of the vessel has been completed the clamps are removed and the suture line inspected; the sutured portion of the artery should then be covered with fascia or muscle. Certain small intra-arterial metal tubes (Tuffier's tubes) have been devised of recent years with a view to placing them inside the vessel in end-to-end anastomosis, and performing the suturing over them. They do not present, however, any advantage over unaided suture and undoubtedly increase the tendency to thrombosis.

Wounds and injuries of veins may be sutured by the same methods as those already described. The suturing is easier to perform, as the blood pressure is far lower, but thrombosis is more likely to occur.

Endo-aneurysmorrhaphy. This operation of Matas consists in various ways of obliterating the sac of an aneurysm by intrasaccular suturing. Any success it may have depends upon the fact that an aneurysmal sac is lined by an endothelium similar to that which lines the normal vessels, and which is capable of healing on suture. Three varieties of the operation are performed:—

(*a*) *Obliterative.* In this case the aneurysmal sac is completely obliterated by suturing, no attempt being made to preserve the lumen of the vessel, which is completely blocked. It is, therefore, most suitable in the case of fusiform aneurysms.

(*b*) *Reconstructive.* Here the sac of the aneurysm is obliterated by suturing in such a way that a portion of the sac is converted into a tube continuous with both ends of the vessel and of approximately the same size, through which the circulation of the blood is able to proceed.

(*c*) *Restorative.* This can be performed only in the case of saccular aneurysms, the aperture of communication between the sac and the arterial lumen being sutured in such a way that the vessel is not obstructed and the sac is then obliterated by sutures.

In all these operations the circulation through the sac must first of all be controlled either by a tourniquet, by means of clamps placed upon the vessels or by temporary ligatures. The aneurysmal sac is then exposed by dissection, due attention being paid to the anatomical structures in the neighbourhood, while it must be specially remembered that neighbouring structures are liable to be grossly displaced, matted or adherent to the aneurysmal sac itself. On no account should the aneurysmal sac be approached by dissection until the circulation central to it at any rate has been temporarily controlled by one of the methods already described. It must then be decided which form of operation is going to be performed, though it may be necessary to open the sac before this can be settled. It is not necessary in any of these operations to dissect the sac free from the surrounding tissues to any great extent.

(*a*) If the *obliterative* operation is decided upon, the sac is freely opened, blood and clot turned out, and the openings of the main vessels and any branches that may enter the sac securely closed by sutures which should pass through all layers of the sac wall and are inserted from the inner side of the sac. The remaining portion of the sac is then completely obliterated by layers of mattress sutures, which draw it together until no space remains. It is not necessary during this operation to free the outer side of the wall of the sac from the surrounding tissues to any great extent. The details of the suturing are given in Fig. 167.

(*b*) *Reconstructive.* Here the sac is exposed and laid open and a length of rubber tubing approximating to the size of the supplying vessel inserted so as to lie along the sac wall, with one of its ends in either end of the main vessel where it enters and leaves the sac. Interrupted sutures are then placed close together to draw the sac wall together over this tube in such a way as to constitute a new lumen for the artery, and before these are finally tied the rubber tubing is drawn out. Over this first layer of sutures another layer is placed to draw the sac wall together further. The remaining portion of the sac is then obliterated by sutures as already described (see p. 290).

(*c*) *Restorative.* This operation is only performed in the case of a saccular aneurysm. The sac is exposed and laid open and the aperture of communication between the sac and the lumen of the main vessel is closed by suturing in such a way that the sac is cut off from the circulation without the lumen of the vessel being obstructed. The remaining portion of the sac is then obliterated by mattress sutures as already described.

The results of these operations are in many ways disappointing, and thrombosis, or further aneurysmal dilatation, is apt to follow. They should, however, be attempted in those cases where ligature of the vessel is highly likely to lead to gangrene.

Excision of the Aneurysmal Sac. This is described on p. 273. It may be found to be a very difficult operation owing to the firm way in which the sac is adherent to surrounding structures. An alternative method which has been practised recently consists in exposing and incising the sac, all hæmorrhage being temporarily controlled, turning out blood and clot, and discovering all openings into the sac whether of the main vessel or branches. Into each of these openings a bougie is passed for a short distance, and by means of two little incisions on either side of the opening through the sac wall the vessel in which the bougie lies is ligatured, the bougie being withdrawn as the ligature is tightened. The sac is then obliterated with mattress sutures (*Syme's operation*).

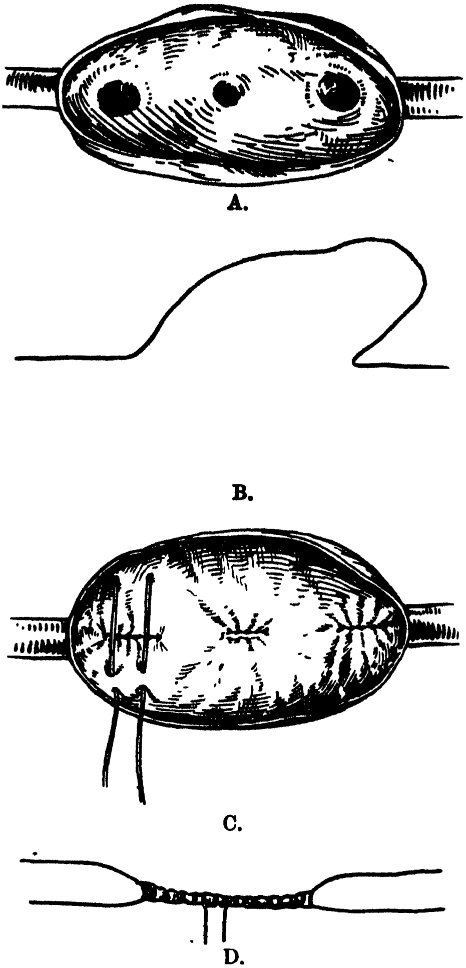


Fig. 167. Matas' obliterative method of suturing an aneurysm: A. The sac and openings of the vessels. B. Section of the same. C. Vessel openings sutured and obliteration of the sac commenced. D. Obliteration complete.

Varicose Aneurysm and Aneurysmal Varix. Though in many cases excision of the communication between the vessels or ligature of both the artery and the vein are the only operations which can be performed on account of anatomical difficulties, these two conditions may be regarded as specially suitable for lateral suture or restorative endo-aneurysmorrhaphy. The operations will have to be performed on both the artery and the vein.

LIGATURE OF ARTERIES

Ligature of an artery in its continuity is an operation which may be performed for the following conditions: to stop hæmorrhage, primary or secondary, for aneurysm, before the removal of limbs or vascular organs, for certain pulsating tumours, to diminish the rate of growth of certain malignant tumours and, finally, as an examination and academic exercise. The ligature material used is usually silk, and in the case of large arteries this should be very strong. In most cases the skin incision is made over the line of the artery, though there are exceptions to this rule, while in most of the operations to be described the artery is approached at the selected spot by dividing the skin and deep fascia and then separating certain muscle groups or individual muscles without cutting their fibres. The divisions between the various muscles or muscle groups can usually be identified by noting that there is generally a thin white line separating the muscles, and through this white line it will sometimes be noticed that small arterial twigs pass, while the situation of the intermuscular septum can often be felt with the finger as a shallow depression. It must be remembered that all arteries lie under the deep fascia. Once the skin and deep fascia are divided, the remainder of the operation can usually be performed with a blunt dissector and retractors without any cutting, while the wound should be kept the same depth throughout. The artery required is usually found lying in contact with a vein, veins or nerves. Its sheath is opened over the centre of the vessel, and the aneurysm needle passed round the artery in a direction so that its point faces away from the most important structure in contact with the artery, *i.e.*, vein or nerve. While this is being done one margin of the incision in the sheath should be held up with forceps. The artery should be displaced from its bed as little as possible and care be taken not to puncture any vein in its vicinity. The aneurysm needle is best passed unthreaded, and by means of it the structures round the vessel should gently be set free. When tying the ligature the artery should not be lifted up into the wound but be kept down by the two forefingers which are tying the knot. In most cases an ordinary reef knot tied with an ordinary ligature is sufficient. Ballance and Edmunds have, however, devised a special knot for this purpose, known as the "Stay Knot." It is performed with two ligatures.

Ligatures on arteries should be tied tightly, but if possible not sufficiently tightly to rupture the inner coat, for this increases the tendency to secondary hæmorrhage. The old-fashioned method of placing two ligatures upon the artery and dividing it between them has nothing to recommend it.

As in most cases no muscles have been divided, but muscle groups have been merely separated, very few deep stitches are necessary, though the deep fascia embracing the muscles must be carefully closed. When a moderately large artery has been ligatured the patient must be kept in bed for at least three weeks while the limb is kept wrapped up in wool and bandages and every effort made to encourage the formation of a collateral circulation (see p. 254). The two complications most to be dreaded are secondary hæmorrhage and gangrene, but both of these are now rarely seen. The latter is most likely to occur where arteriosclerosis and hardened arteries are present, after severe hæmorrhage, if the venous return is impaired by tight bandages, or owing to the vein being injured, ligatured or thrombosed. This is, however, not invariably the case, and certain authorities hold that ligaturing the vein as well as the artery decreases the liability to gangrene, as it increases the vascular congestion of the limb and diminishes venous back pressure. It must be remembered, however, that this theory was only elaborated in the course of military practice, and it does not necessarily hold true in the case of patients with diseased arteries or deficient vitality.

LIGATURE OF INDIVIDUAL ARTERIES

The standard operations for ligature of individual arteries at different situations are usually performed by definite incisions, by passing between definite muscle groups, and by identifying and recognising certain definite structures which may be regarded as "rallying points," and it is only possible in this work to give the main indications of the different features of each operation.

The Innominate Artery.

Surface Marking. The line joining the upper border of the right sternoclavicular articulation to a point immediately to the right of the mid-point of the manubrium sterni.

An angular *incision* is made running three inches down the anterior border of the sternomastoid and for three inches along the upper border of the inner third of the clavicle. The platysma, the deep fascia, anterior jugular vein, inner half of the sternomastoid, the sternohyoid and sternothyroid muscles are divided. The carotid sheath is identified and opened, the carotid artery exposed and followed down to the innominate. It is not usually necessary to remove part of the sternum or clavicle. Great care must be taken of the internal jugular, the two innominate veins, the inferior thyroid plexus, the vagus nerve and the pleura. The site of division and the length of this artery vary greatly, and thus the operation may be very difficult or easy.

Collateral Circulation. (1) Intercostal branches of the aorta with the superior intercostal branch of the subclavian and with the thoracic branches of the axillary and internal mammary arteries, also with the musculophrenic branch of the internal mammary; (2) the deep epigastric artery with the termination of the internal mammary; (3) between the branches of the two external carotids and also through the circle of Willis.

The Common Carotid Artery.

Surface Marking. A line drawn from the sternoclavicular articulation to a point midway between the tip of the mastoid process and the angle of the jaw, and the part of this line below the upper border of the thyroid cartilage, the head being turned towards the opposite side. This vessel may be ligatured above or below the anterior belly of the omohyoid.

(*a*) **Above the Omohyoid.** Here the vessel is more superficial.

Incision. Three inches long in the line of the artery, with its centre opposite the cricoid cartilage. The skin and deep fascia are divided, the anterior border of the sternomastoid defined and the muscle retracted backwards. The omohyoid muscle is identified and retracted downwards, and the sheath is then seen with the descendens hypoglossi nerve lying upon it. The sheath is opened on the inner side and the artery exposed. In passing the needle care must be taken not to include the vagus, the sympathetic or internal jugular.

(*b*) **Below the Omohyoid.**

Incision. Three inches long over the line of the artery and extending up from the sternoclavicular joint. The sternomastoid is drawn outwards, the sternohyoid and sternothyroid muscles drawn inwards, and it may be necessary to detach part of these muscles from the sternum. The omohyoid is then found and drawn upwards and the sheath exposed. It will probably be necessary to tie and cut a portion of the inferior thyroid venous plexus. The sheath is opened on the inner side, while in the case of the left artery the internal jugular vein will lie in front of it.

Collateral Circulation. The superior with the inferior thyroid, the profunda cervicis with the princeps cervicis, various branches of the two external carotids and the circle of Willis.

In spite of this free collateral circulation it must be remembered that in many cases of ligature of the common carotid, certainly over 20 per cent., hemiplegia follows either immediately or in the course of a few days from the cerebral anæmia and cerebral softening produced and this condition frequently has a fatal ending.

The External Carotid Artery.

Surface Marking. This is a prolongation of the surface marking of the common carotid artery, the vessel commencing at the upper border of the thyroid cartilage. The artery is best tied below the digastric muscle and between its lingual and superior thyroid branches.

Incision. In the line of the artery three inches long, with its centre at the level of the hyoid bone. The sternomastoid is identified and drawn out, the posterior belly of the digastric muscle and the hypoglossal nerve are identified above and drawn upwards and the apex of the greater cornu of the hyoid bone exposed. The sheath is opened just below this spot and the aneurysm needle passed. Many glands and veins will be encountered, while the superior laryngeal nerve lying just behind the artery must be avoided.

Collateral Circulation. The profunda cervicis with the princeps cervicis and the branches of the vertebral and external carotid arteries on the two sides.

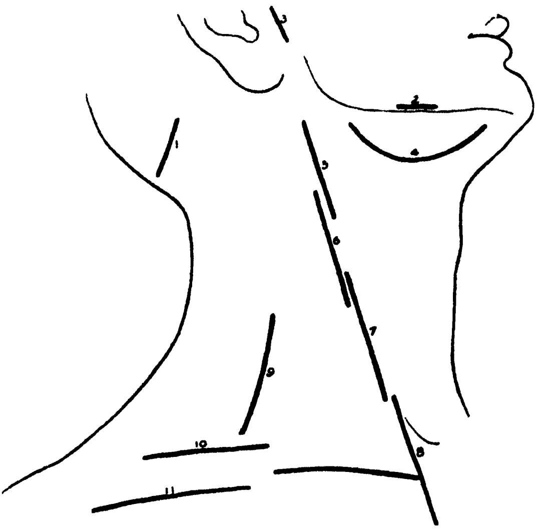


FIG. 168. Incisions for ligature of the arteries of the head and neck: (1) Occipital. (2) Facial. (3) Superficial temporal. (4) Lingual. (5) External carotid. (6) and (7) Common carotid. (8) Innominate. (9) Vertebral. (10) Subclavian (third part). (11) Axillary (first part).

The Internal Carotid Artery.

Surface Marking. This is the same as that of the external carotid artery, the internal vessel lying on a deeper plane and a trifle external to the external artery. It can only be ligatured just above its commencement.

Incision. This is the same as that for the external carotid. The sternomastoid is pulled backwards, the digastric is pulled upwards, the external carotid artery pulled forwards, and the vessel will then be found lying deeply in the neck. Care must be taken not to injure the jugular vein, the vagus and the sympathetic trunk.

Collateral Circulation. This occurs through the circle of Willis. It must be remembered that ligature of this vessel is followed by hemiplegia almost as frequently as is ligature of the common carotid.

The Superior Thyroid Artery. This is the first branch of the external carotid, and it is ligatured with an incision similar to that for ligaturing the vessel from which it comes off, the external carotid artery being identified and followed down until its branch appears. The artery is sometimes ligatured in Graves' disease.

The Lingual Artery. This artery may be ligatured in two places: either at its origin from the external carotid or else beneath the hyoglossus in the submaxillary triangle. It is chiefly done before removing the tongue for carcinoma.

(*a*) **At its Origin.** (First Part.) The incision here is the same as that for tying the external carotid, the artery being the second branch given off by this vessel. The external carotid artery is exposed and followed down till the lingual artery is seen leaving it and lying upon the middle constrictor.

(*b*) **Under the Hyoglossus.** (Second Part.) The patient lies on his back with the neck extended and the head turned to the opposite side.

Incision. This is not over the line of the vessel, but is a curved incision lying under the lower jaw, concave upwards, starting half an inch below and outside the symphysis, passing down to the hyoid bone and curving up again to the angle of the jaw. This flap is turned up, the skin, platysma and deep fascia being divided. The submaxillary gland is identified and hooked up over the jaw. The two bellies of the digastric muscle are then exposed, with the mylohyoid muscle lying beneath the front part of the anterior belly. The tendon of the digastric muscle is drawn downwards and the hyoglossus muscle is seen in its angle with its fibres passing vertically upwards and the hypoglossal nerve passing across it and running forwards to disappear under the mylohyoid muscle. This nerve is drawn up and the fibres of the hyoglossus muscle divided transversely about a quarter of an inch above the hyoid bone. The lingual artery will be seen lying beneath the hyoglossus upon the middle constrictor. It must be remembered that the hyoglossus is a very thin muscle, and if it is divided too deeply the middle constrictor may be incised and the pharynx opened.

No collateral circulation is formed after ligature of this vessel.

The Facial Artery. This crosses the lower jaw at a point immediately in front of the masseter. It may be ligatured at two points:—

(*a*) **Just above its Origin.** This vessel is the fourth branch of the external carotid; when it leaves the main vessel (*i.e.*, a short distance above the greater cornu of the hyoid bone), it is ligatured by an operation exactly similar to that for tying the external carotid.

(*b*) **Where it crosses the Mandible.**

Incision. A horizontal incision 1 inch long parallel to and just below the lower jaw. The skin and incision are then drawn up over the bone. The artery will be found lying upon the bone just in front of the masseter.

The collateral circulation is formed with the opposite facial artery and branches of the superficial temporals.

The Superficial Temporal Artery. This is best ligatured where it lies upon the zygoma just in front of the ear.

Incision. One and a half inches long vertically, in the line of the artery, with its centre on the zygoma. The vessel is easily exposed, but care must be taken to preserve the auriculotemporal nerve.

The collateral circulation is formed by the facial vessels and other arteries supplying the scalp.

The Occipital Artery. This is a branch from the back of the external carotid artery, coming off just above the great cornu of the hyoid bone. It may be tied in two places.

(*a*) **In the Anterior Triangle,** at its origin. Here the operation is similar to ligature of the external carotid artery from which the vessel springs.

(*b*) **In the Mastoid Region.**

Incision. Two inches long from the back of the apex of the mastoid process in the direction of the external occipital protuberance. The posterior part of the sternomastoid, the splenius capitis and the trachelomastoid are divided, and the artery is then seen emerging from the groove under the mastoid process in which it lies. The collateral circulation is then established by means of the other arteries supplying the scalp.

The Middle Meningeal Artery.

(*a*) **The Anterior Branch.** A semicircular flap of about 1½ inches radius is reflected downwards in the temporal region so as to permit of the skull being trephined at a point 1½ inches behind the external angular process of the frontal bone and 1½ inches above the zygoma, the temporal muscle and fascia being split vertically. An opening of about 1½ inches diameter is made in the skull and the artery will be found either running in a groove or channel in the bone or else lying upon the dura. In the former case the vessel should be occluded by crushing the bone in upon it or by forcing wax or a small wooden peg into the bony canal, and in the latter case by underrunning it with a stitch.

(*b*) **The Posterior Branch.** This may be exposed by trephining the skull in a situation similar to the above, only about ½ inch lower. Farther back this branch can be exposed by trephining 1½ inches above the centre of the base of the mastoid process.

(*c*) **The Main Trunk.** This can be ligatured by trephining the skull at the same point as for the anterior branch and cutting away the bone downwards for a short distance. It will be easier to secure the vessel if the dura mater is pushed away from the bone for a short distance.

The Subclavian Artery. This artery has been tied in any of its three parts. Ligature of the first part is practically the same operation as ligature of the innominate artery (see p. 294), while the second part is practically never tied, as it lies under the scalenus anticus muscle.

Surface Marking. With the arm against the side, a line drawn from the centre of the sternoclavicular articulation to the centre of the clavicle and describing a curve which reaches upwards about ¾ inch above the clavicle.

Ligature of the Third Part.

Incision. With the patient on his back, the arm drawn down and the head turned over to the opposite side, the skin of the neck is drawn down over the clavicle and an incision 3 inches long is made over the middle third of the clavicle; the skin is then allowed to retract upwards and the incision comes to lie ½ inch above the clavicle. The external jugular vein should be preserved, if possible—otherwise ligatured and then divided. The borders of the sternomastoid and trapezius may be seen and should be drawn forwards and backwards respectively, the deep fascia incised and the posterior belly of the omohyoid sought for and drawn up.

The transverse cervical and suprascapular arteries must be avoided. The external border of the scalenus anticus is then sought for and followed down with the finger to the scalene tubercle on the first rib. When the finger rests on this tubercle, the subclavian vein will be in front of the finger and farther down into the chest, while the artery will be felt beneath the pulp of the finger lying in a groove on the rib and can then be exposed. It will appear to have an almost vertical course there, the cords of the brachial plexus being above, outside and behind it. Care must be taken in passing the ligature not to include either of these cords, and also not to wound the pleura or the subclavian vein.

Collateral Circulation. The intercostals and branches of the internal mammary with the thoracic branches of the axillary, and other branches of the axillary with the suprascapular and posterior scapular arteries.

The Inferior Thyroid Artery. This vessel is occasionally ligatured for exophthalmic goitre.

Incision. This is the same as for ligature of the common carotid artery below the omohyoid. The sternomastoid and the whole of the carotid sheath are retracted outwards, while it may be necessary to divide the sternomastoid and sternohyoid muscles. To the inner side of the sheath the tubercle of the sixth cervical vertebra should be found, and immediately below this the artery will be seen running directly inwards. Great care must be taken of the recurrent laryngeal nerve, which splits into several branches before entering the larynx (see p. 352).

The Vertebral Artery. There are two methods of performing this operation. (*a*) The first commences in a way exactly similar to ligature of the inferior thyroid artery. When this vessel is found it is drawn downwards and the vertebral artery is then exposed by blunt dissection just below and behind the tubercle of the sixth transverse process and just before it enters the bone. Great care must be taken of the branches of the cervical plexus close by. (*b*) By the other method an incision is made along the lower half of the posterior border of the sternomastoid, which, with the carotid sheath, is retracted inwards. The scalenus anticus and the phrenic nerve are exposed and the sixth cervical transverse process defined in the gap between this muscle and the longus colli. Just below this the vertebral artery is found entering its bony canal. As before, the cervical sympathetic must be avoided.

Collateral Circulation. This is established through the circle of Willis.

The Internal Mammary Artery. This runs down parallel to and about ½ inch outside the border of the sternum.

Incision. A transverse incision 1½ inches long in the second or third intercostal space and running out from the border of the sternum. The intercostal muscles and aponeurosis are divided together with a few fibres of the pectoralis major. The artery lies upon the pleura and care must be taken not to wound this structure or the lung underneath. If preferred a small portion of the inner end of the second or third costal cartilages may be resected subperiosteally and the artery exposed in this way.

The Axillary Artery. Only the first and third parts of this artery can be ligatured.

Surface Marking. With the arm at right angles to the trunk and the forearm supinated, draw a line from the central point of the clavicle to the middle of the antecubital fossa; in this line, which represents both arteries, the axillary artery ends and the brachial artery commences at the lower border of the posterior axillary fold,

(*a*) **Ligature of the First Part.** The arm should lie by the side and the point of the shoulder not be depressed.

Incision. This is 4 inches long and immediately below the outer two-thirds of the clavicle—some surgeons advise that this incision should form a curved flap, convex downwards, which can be reflected up. The clavicular and sternal portions of the pectoralis major are separated from each other without cutting and the costocoracoid membrane and pectoralis minor exposed. The above membrane is divided, pectoralis minor drawn down and the subclavius muscle drawn up, the branches of the thoracic axis artery drawn aside, the axillary vein drawn in and the artery exposed. Care must be taken not to include the vein or one of the cords of the brachial plexus in the ligature.

Collateral Circulation. If the ligature is above the thoracic axis branch, this is the same as in the ligature of the third part of the subclavian (see p. 297). If below this branch it is established by the humeral branches of the thoracic axis with the anterior circumflex vessels and the perforating intercostal vessels. Also by means of the suprascapular and posterior scapular vessels with branches of the subscapular and posterior circumflex.

(*b*) **Ligature of the Third Part.** Here the arm must be abducted to a right angle, and the operator stands between it and the body.

Incision. Three inches long in the line of the artery. The neurovascular bundle is exposed in the axilla, after drawing the coracobrachialis outwards. The median and musculocutaneous nerves are first seen, and these are also drawn out and the artery is then seen rather overlapped by the vein. Care must be taken not to include the ulnar or internal cutaneous nerves in this ligature.

Collateral Circulation. This will depend upon where the ligature is applied; but the following vessels are those which enter into it: the thoracic axis and its branches, the suprascapular, posterior scapular, and subscapular, the anterior and posterior circumflex, the superior profunda, the intercostals and the long thoracic.

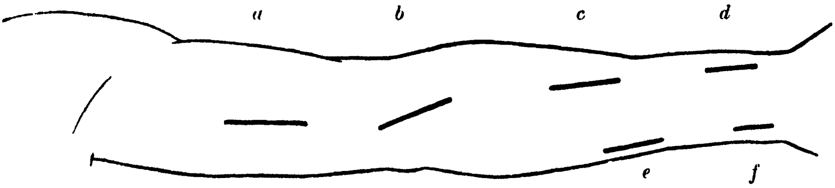


FIG. 169. Incisions for ligature of vessels in the arm: (*a*) Brachial artery. (*b*) Brachial artery at the elbow. (*c*) and (*d*) Radial artery. (*e*) and (*f*) Ulnar artery.

The Brachial Artery. This artery is ligatured in two places.

Surface Marking. This is a continuation of the line given above in the surface marking of the axillary artery.

(*a*) **At the Middle of the Upper Arm.** The arm is abducted from the side to a right angle and held fully supinated; it should not be laid upon a trolley or side table, as this displaces the vessels; the surgeon must stand between the arm and the trunk.

Incision. Two and a half inches long in the line of the vessel. The basilic vein is drawn backwards and the biceps muscle identified and drawn forwards and outwards. The artery is found lying upon the triceps with the median nerve in front of it, and this latter structure must be drawn aside before passing the aneurysm needle. There is no excuse for mistaking the basilic vein for the artery, as the former is above and the latter beneath the deep fascia. An alternate method consists in deliberately opening the sheath of the biceps and passing through it, so as to approach the vessel from the front.

Ligature of this artery is by no means as simple as it seems.

Collateral Circulation. This depends upon whether the vessel is tied above or below the superior profunda. The vessels forming the collateral circulation are the superior profunda, the circumflex vessels, and the free anastomosis round the elbow joint.

(*b*) **At the Bend of the Elbow.** The position is the same except that the arm may now rest upon a table.

Incision. Two inches long starting at the middle of the antecubital fossa and running up and inwards parallel to the inner border of the biceps. The median basilic vein is drawn inwards, the bicipital fascia cut and the artery found in the loose fat with the median nerve on its inner side and the biceps tendon on its outside.

The *collateral circulation* is due to the superior profunda vessel and the anastomosis round the elbow joint.

The Ulnar Artery. This vessel is ligatured in its upper, middle or lower thirds.

Surface Marking. The lower two-thirds of a line joining the internal condyle of the humerus to the radial side of the pisiform, and above, a line from the centre of the antecubital fossa to the upper end of the above line.

(*a*) **In its Upper Third.** The arm is drawn away from the body and placed upon a table fully supinated.

Incision. Two inches long in the line of the artery downwards from the midpoint between the condyles of the humerus. The bicipital fascia is divided, the border of the pronator radii teres discovered and the muscle drawn to the ulnar side together with the median nerve and the artery tied just as it passes under this muscle.

(*b*) **In its Middle Third.**

Incision. Three inches long in the line of the vessel. The muscles are exposed and the interval between the flexor carpi ulnaris and the flexor sublimis digitorum discovered. At the bottom of this space the artery is found lying upon the flexor profundus digitorum and with the ulnar nerve lying just to its ulnar side.

(*c*) **In its Lower Third.**

Incision. Two inches long in the line of the vessel, and running up from about ½ inch above the pisiform bone. The vessel is found lying between the tendons of flexor carpi ulnaris and flexor sublimis digitorum with the nerve on its ulnar side.

Collateral Circulation. This is established by the anterior and posterior interosseous arteries and the carpal and palmar arches.

The Radial Artery. This vessel is ligatured in four places.

Surface Marking. A line drawn from the midpoint of the antecubital fossa to the base of the styloid process of the radius. Here it turns to the back of the wrist and passes across the anatomical snuff box.

(*a*) **In its Upper Third.**

Incision. Two inches long in the line of the vessel. The space between the pronator radii teres and the supinator longus muscles is sought for; the muscles are separated and the artery exposed. At this point the radial nerve lies at some distance to the radial side of the artery.

(*b*) **In its Middle Third.**

Incision. Three inches long in the line of the artery. The inner border of the supinator longus muscle is sought for and the muscle is retracted outwards. The artery is then exposed lying upon the insertion of the pronator radii teres with the radial nerve at its outer side.

(*c*) **In its Lower Third.**

Incision. One and a half inches long in the line of the vessel. The vessel is exposed and found lying between the tendons of the supinator longus and flexor carpi radialis.

(*d*) **At the back of the Wrist.**

Incision. A vertical one, 1 inch long, crossing the anatomical snuff box midway between the tendons which form its boundaries. The artery is exposed deeply in this space; care must be taken of the tendon sheaths and also not to tie one of the superficial veins in mistake for the vessel.

Collateral Circulation. This is established by means of the anterior and posterior interosseous vessels and the carpal and palmar arches.

The Intercostal Arteries. As each of these vessels lies in a groove under cover of a rib, except at the posterior part of the intercostal space, a 2-inch incision is made over the rib, and about 1½ inches of the rib are resected subperiosteally. The periosteum beneath the rib is then divided and the artery exposed.

The Abdominal Aorta. This has been performed on at least sixteen occasions, one patient having survived for 48 days and one for 10 days. The artery divides at a point ½ inch to the left of the midpoint of the line joining the highest points of the iliac crests.

Incision. The abdomen is opened by a left paramedian incision, with its centre level with the umbilicus, and the intestines are pushed upwards and to the right and packed off. The peritoneum over the artery is divided, the inferior mesenteric vessel exposed and retracted, and the aorta is ligatured half-way between its bifurcation and the origin of the inferior mesenteric.

Collateral Circulation. This is established by means of the internal mammary, deep and superficial epigastric arteries, the intercostal vessels, and circumflex iliac vessels and by certain of the rectal vessels.

The Common Iliac Artery.

Surface Marking. If a line is drawn from the point of division of the abdominal aorta (see p. 300), to the middle point of the line joining the anterior superior iliac spine and the symphysis pubis, the upper third of this line represents the course of the common and the lower two-thirds the course of the external iliac. This artery may be ligatured by either the intraperitoneal or the extraperitoneal method, the former being the modern operation.

(*a*) **Intraperitoneal Method.**

Incision. A 4-inch paramedian incision is made, the peritoneum opened and the intestines packed out of the way. The posterior peritoneum over the vessel is incised, the ureter seen and avoided and the artery tied, care being taken of the common iliac vein which lies behind the artery.

(*b*) **Extraperitoneal Method.**

(1) *Anterior Incision.* This should be about 5 or 6 inches long, running for 2 inches parallel to and 1½ inches above the outer half of Poupart's ligament and then turning slightly upwards for 3 or 4 inches; all layers of the abdominal wall are divided as far as possible by splitting the muscles, until the extraperitoneal fat is reached; the peritoneum is then stripped up from the iliac fascia until the external iliac artery is seen, and this is followed up to the common iliac vessel.

(2) *Lateral Incision.* This extends from the tip of the twelfth rib to just above the iliac crest and then runs inwards and forwards to the anterior superior iliac spine; the patient must be turned well over upon the opposite side; the muscles are cut, the peritoneum stripped up and the artery found and ligatured as in the preceding method.

Collateral Circulation. The superficial and deep epigastric vessels and the circumflex iliac anastomose with the lumbar, superior epigastric and intercostal vessels; the iliolumbar and lateral sacral vessels meet the lumbar and middle sacral branches, while the obturator, hæmorrhoidal and vesical arteries of the two sides anastomose. In the female the uterine and ovarian vessels anastomose with each other and with those of the opposite side.

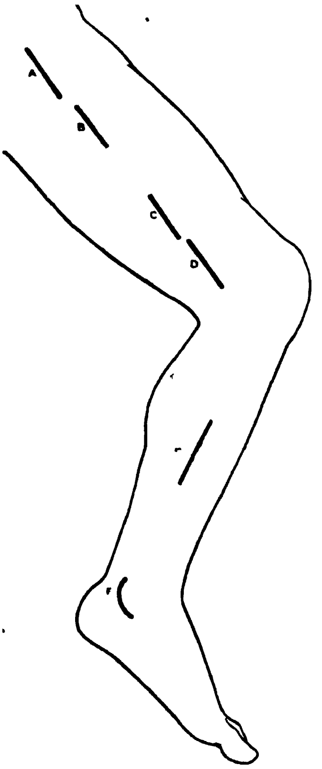


FIG. 170. Incisions for ligaturing: (*a*) The common femoral. (*b*) The superficial femoral in Scarpa's triangle. (*c*) The superficial femoral in Hunter's canal. (*d*) The upper half of the popliteal. (*e*) The posterior tibial in its middle third. (*f*) The posterior tibial at its lower end.

The External Iliac Artery. (For surface marking see above.)

Though it is easy to ligature this vessel by opening the peritoneum, this is not necessary, and one or other of the two extraperitoneal methods are usually employed.

(*a*) **Astley Cooper's Incision.** Four inches long, parallel to the outer half of Poupart's ligament, ½ inch above it and extending to the inner side of its midpoint. The external oblique is split parallel to its fibres and the lower arched borders of the internal oblique and transversalis muscles are retracted upwards and outwards: the transversalis fascia is cut and the peritoneum drawn up till the vessel is exposed. The epigastric and circumflex vessels must be carefully preserved and care must be taken not to lift the vessel up with the peritoneum, and not to damage the external iliac vein. The artery should be tied 1 inch above Poupart's ligament.

(*b*) **Abernethy's Incision.** Four inches long, starting about 1½ inches above and inside the anterior superior iliac spine, curving and running down ½ inch above and parallel to the outer half of Poupart's ligament to its midpoint. The external and internal oblique and the transversalis muscle and fascia are divided, and the peritoneum drawn up as in the preceding operation. By this operation the artery is tied higher up than in Cooper's operation and a better exposure is obtained.

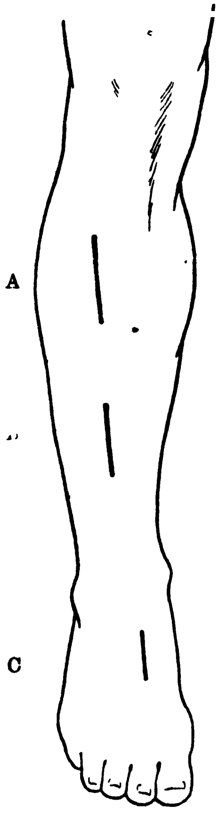


FIG. 171. Incisions for ligaturing: (*a*) and (*b*) The anterior tibial artery. (*c*) The dorsalis pedis artery.

Collateral Circulation. The superficial and deep epigastric vessels join with the superior epigastric, lumbar and intercostal branches, the gluteal and sciatic with the two circumflex and branches of the profunda femoris (crucial anastomosis), the obturator with the internal circumflex, and the gluteal with the deep and superficial circumflex iliac and external circumflex branches.

The Deep Epigastric Artery. This artery is best ligatured by making an incision similar to Battle's appendix incision (see Vol. II.), opening the rectus sheath ½ inch inside the semilunar line, drawing the rectus inwards and tying the artery as it crosses the semilunar fold of Douglas.

The Common and Superficial Femoral Arteries.

Surface Marking. With the thigh abducted, externally rotated, and slightly flexed, a line drawn from the midpoint between the anterior superior iliac spine and the pubic symphysis to the adductor tubercle. The artery may be ligatured in three places.

(*a*) **Just below Poupart's Ligament (Common Femoral).**

This is rarely performed, as the collateral circulation is not so good as after ligature of the external iliac, and the latter operation is therefore preferable.

Incision. With the limb in the above position, 2 inches long in the line of the vessel immediately below Poupart's ligament. Superficial veins and lymphatic glands must be avoided and the sheath should be opened on the outer side.

Collateral Circulation. The obturator, internal pudic and circumflex iliac anastomose respectively with the internal circumflex, external pudic and external circumflex, while the crucial anastomosis is also important.

(*b*) **At the Apex of Scarpa's Triangle.** The so-called site of election.

Incision. With the limb in the above position, 3 inches long in the line of the vessel, reaching up to 3 inches below Poupart's ligament. The inner border of the sartorius is exposed and retracted outwards. The artery is then exposed in its sheath with the vein lying behind it; care must be taken of the branches of the internal saphenous vein and the long saphenous nerve.

Collateral Circulation. Between the external circumflex and the perforating branches of the profunda femoris and the muscular branches of the femoral and popliteal vessels and the articular branches of the latter.

(*c*) **In Hunter's Canal.**

Incision. With the limb in the above position, 3 inches long in the line of the artery, at the centre of the thigh. The sartorius is exposed with its fibres running down and inwards, its outer border defined and the muscle drawn inwards. The fascia forming the roof of the canal is then incised and the artery exposed: the vein lies behind, the long saphenous nerve crosses the vessel from outside to inside, and the nerve to the vastus internus lies to the outer side of the artery.

Collateral Circulation. This is established in the same way as that described above, chiefly through the profunda femoris and its branches.

The Popliteal Artery.

This artery may be ligatured in either the upper or the lower part of the popliteal space.

Surface Marking. Commencing at the adductor tubercle, the artery runs first slightly outwards and then down the middle of the popliteal space.

(*a*) **In the upper part of the Popliteal Space.** This is the better operation.

Incision. With the limb abducted and everted, 4 inches straight up along the inner side of the thigh from the adductor tubercle. The adductor magnus tendon is exposed and drawn forwards; the long saphenous nerve and sartorius and semimembranosus muscles are drawn backwards together with the gracilis. The artery is then found lying close to the bone, buried in loose fat and connective tissue. Care must be taken not to mistake the vein for the artery.

(*b*) **In the lower part of the Space.**

Incision. With the patient prone or semiprone and the leg extended, 4 inches long from the central point of the popliteal space and running straight down the midline. The heads of the gastrocnemius and the internal popliteal nerve are drawn aside. The vein is then encountered, and this together with the nerve drawn to the inner side, and the artery is then seen lying on the bone.

Collateral Circulation. This is established by means of the free anastomosis round the knee joint.

The Posterior Tibial Artery. This artery may be ligatured in three places.

Surface Marking. A line drawn from the central point of the popliteal space, down the back of the calf to a point about ½ inch below and behind the tip of the internal malleolus.

(*a*) **In its Middle Third.**

Incision. Four inches long parallel to the tibia and ½ inch behind its internal border in its middle third, the leg being placed on its outer side with the knee fixed. The long saphenous vein and nerve are drawn backwards and the gastrocnemius muscle, if seen, is drawn back. The aponeurosis of the soleus is then seen, and incised throughout the whole length of the wound; the muscle fibres are cut, and the aponeurosis again incised upon the deeper surface of the muscle; the muscle and the aponeurosis are then drawn backwards and the vessel is found lying upon tibialis posticus with the internal popliteal nerve upon its outer side. Care must be taken not to divide the flexor longus digitorum with the soleus.

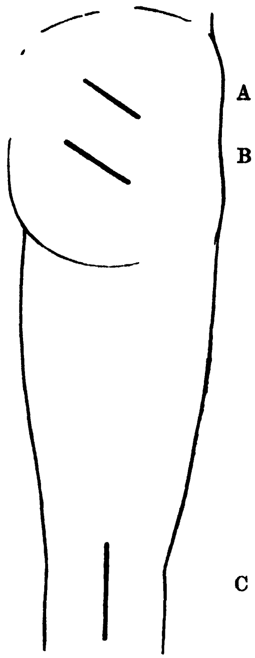


FIG. 172. Incisions for ligaturing: (*a*) The Gluteal artery. (*b*) The Sciatic artery. (*c*) The Popliteal artery.

(*b*) **In its Lower Third.**

Incision. Two and a half inches long in the line of the vessel, midway between the inner border of the tibia and the tendo Achillis. The artery is found lying upon the flexor digitorum longus under the deep fascia with the nerve on its outer side.

(*c*) **Behind the Internal Malleolus.**

Incision. A curved 2-inch incision about ½ inch behind the malleolus.

The internal lateral ligament is divided and the artery is found lying between the tendons of flexor longus digitorum and flexor hallucis.

Collateral Circulation. This is formed by the muscular and other branches of the peroneal and anterior tibial vessels.

The Peroneal Artery. This is best tied in the middle of the calf of the leg.

Incision. With the patient turned upon his opposite side and the leg laid upon its inner side, a 3-inch incision is made in the middle of the leg over the posterior border of the fibula. The soleus muscle is exposed and incised or retracted. The attachment of the flexor longus hallucis is then exposed and must be incised until the artery is found lying upon the postero-internal border of the fibula.

The Anterior Tibial Artery.

Surface Marking. The line from a point midway between the head of the fibula and the outer tuberosity of the tibia to a point midway between the two malleoli. The vessel may be tied in three places.

(*a*) **In its Upper Third.**

Incision. Four inches long in the line of the artery. The intermuscular space between the tibialis anticus and the extensor communis digitorum is identified, these muscles separated, and the artery will be found lying upon the interosseous membrane, with the nerve on its outer side. The operation will be easier if the ankle is dorsiflexed.

(*b*) **In its Middle Third.**

Incision. Three inches long in the line of the artery. The interval between tibialis anticus and extensor communis digitorum is again found. On separating these muscles the extensor longus hallucis is found and is drawn aside. The artery lies under this, with the nerve lying in front of it.

(*c*) **In its Lower Third.**

Incision. Two and a half inches long in the line of the artery just above the ankle. The anterior annular ligament is partly divided and the vessel found lying between the tendons of tibialis anticus and extensor hallucis, and rather under cover of the latter, with the nerve on its outer side.

Collateral Circulation. This is formed by the muscular and other branches of the posterior tibial and peroneal arteries.

The Dorsalis Pedis Artery.

Surface Marking. A line from the midpoint between the two malleoli to the commencement of the first intermetatarsal space.

Incision. With the foot plantar-flexed, 1½ inches long in the line of the vessel and 1 inch below the ankle. The artery is found lying between the tendons of extensor longus hallucis on the inner side and the innermost tendon of extensor longus digitorum on the outer side. The innermost tendon of extensor brevis digitorum may have to be pulled aside.

The Internal Iliac Artery. This vessel extends from the sacroiliac synchondrosis to the upper border of the great sacrosciatic foramen.

Incision. A 4-inch paramedian incision is made below the umbilicus, the peritoneum is opened and the intestines and omentum packed out of the way. The bifurcation of the common iliac artery is sought, the ureter pulled aside after the posterior peritoneum is incised, and the artery identified and ligatured.

Collateral Circulation. This is formed by the union of the iliolumbar, lateral sacral, gluteal and obturator vessels with the deep circumflex iliac, middle sacral and external circumflex vessels and also by the junction of the obturator, internal pudic, vesical and hæmorrhoidal vessels of the two sides.

The Sciatic and Internal Pudic Arteries. The point where these vessels emerge from the pelvis is the junction of the middle and distal thirds of a line joining the posterior superior iliac spine to the outer part of the tuberosity of the ischium.

Incision. Four inches long in the direction of the fibres of the gluteus maximus with its centre at the above point. The fibres of the gluteus maximus are separated and the pyriformis muscle exposed in the bottom of the wound and the distal border of this muscle sought and traced up to the foramen where the vessel will be found. The internal pudic lies upon the tip of the ischial spine, and is deeper and nearer to the midline than the sciatic is.

The Gluteal Artery. This vessel emerges from the pelvis at a point corresponding to the junction of the inner and middle thirds of a line joining the posterior superior iliac spine to the tip of the great trochanter.

Incision. Four inches long parallel to the fibres of the gluteus maximus and with its centre at the above point. The fibres of the gluteus maximus are separated and the pyriformis muscle exposed beneath it. The upper border of the muscle and the gap between it and the gluteus medius are exposed, the two muscles separated, and the artery found lying upon the bone at the sacrosciatic foramen.

Operations on the Periarterial Sympathetic Plexus. These are often undertaken for various forms of gangrene. A description of the operation with its indications will be found on p. 378.

CHAPTER XI

DISEASES OF THE LYMPHATIC SYSTEM

Surgical Anatomy. The lymphatic system consists of two main structures, the lymphatic vessels and the lymphatic glands. The lymph which passes out through the walls of the capillaries nourishes the tissues and then collects in intercellular spaces and various sacs and cavities, whence it passes into the lymphatic vessels, which lead back towards the trunk, joining and gradually getting bigger and bigger until finally the lymph flows into the thoracic duct and the right lymphatic duct, and thence into the blood stream again. The structure of a lymphatic vessel is similar to that of a vein, though its walls are far thinner and there are many valves : though these vessels are present in nearly all tissues of the body, they are especially numerous in the fatty subcutaneous tissues and in the sheaths of blood vessels. In their course towards the thoracic duct the lymphatic vessels pass into and through lymphatic glands, these glands being more marked a feature in man than in any other animal, and being arranged in definite groups or chains in several parts of the body. They consist of round encapsulated structures, having a hilum at which blood and lymph vessels enter and leave the gland, and containing a thin connective tissue stroma, the spaces of which are densely filled with leucocytes. In passing through the glands the lymph is filtered and waste products, foreign particles, cells and organisms are extracted from it, chiefly by the aid of the leucocytes, so that in this way the entrance of bacteria into the body is greatly retarded ; the lymphatic glands, therefore, may be regarded as an important first line of defence which will prevent organisms from getting into the general blood stream.

A knowledge of the arrangement of the vessels and glands and of the region from which the lymphatics drain into any particular group of glands is of great importance, not only in connection with the spread of various infective processes, both septic and tuberculous, but also because it appears that one of the most important ways in which carcinoma spreads about the body is *via* the lymphatic vessels. The arrangement of lymphatic glands into groups is practically constant in all individuals, while the number in any particular group or chain varies and probably changes from time to time in the same individual. After glands have been removed by the surgeon, it is quite possible for new ones to be formed, while various bodily processes may cause new glands to form or glands to disappear. This is seen well in the axillary glands during lactation, during which time they increase in number and size, but after lactation is over many of them will disappear and become converted into fat and fibrous tissue. Lymphoid tissue has a marked tendency to become changed into fat and fibrous tissue after middle age, but the onset of any irritation or disease will often turn it back into lymphoid tissue again.

The groups in which these glands are distributed throughout the body are as follows (for a fuller description see pp. 66–69): —

The Abdomen and **Thorax** contain innumerable glands, the arrangement of which is too complicated to be dealt with here, though an indication of their importance and situation will be given when dealing with the surgery of those regions.

The Arm. There are no lymphatic glands in the arm below the elbow. Just above the elbow is the *epitrochlear gland*, which lies about an inch and a half above the internal condyle of the humerus, while occasionally a few small *cubital glands* will be found lying in or just above the bend of the elbow ; of these the epitrochlear is the most important. They all drain the inner and ulnar side of the forearm and the two ulnar fingers. They are thus frequently infected in septic conditions of that portion of the fingers and arm, and they are often enlarged and shotty in syphilis. The lymphatics of the remaining parts of the hand and forearm pass straight up into the axillary glands.

The *axillary glands* are numerous and important, receiving as they do the lymph from the whole arm, the shoulder, the side of the chest and of the abdomen down to the umbilicus, the breast, and the upper part of the back. They are thus frequently involved by carcinoma and by septic or tuberculous infections. They are usually divided for purposes of description into the following groups: the *pectoral*, which lie immediately under the pectoralis major muscle; the *subscapular*, which lie along the subscapular artery; the *central*, which are in the middle of the axillary fat, and the *apical*, which lie far up in the apex of the axilla, though it must be understood that all these groups form a continuous chain. The vessels from the epitrochlear and cubital glands pass up into the axillary glands, while the axillary glands themselves drain the lymph partly into the main lymph duct on either side of the chest and partly into the lower and deeper of the cervical glands. A few small *cephalic glands* are to be found along the cephalic vein between the deltoid and pectoralis major; these receive lymph from the radial side of the arm and hand, and drain into the upper axillary glands.

The Leg. There are no glands in the leg below the knee, but in the popliteal space there is a large group, a few of which are quite superficial and near the termination of the external saphenous vein, but the majority of which lie deeply placed in this space. They receive lymph from the foot, especially from the sole and outer side of the foot, and drain it into the inguinal glands higher up. The lymphatic vessels of the remainder of the foot and leg pass straight up into the inguinal glands. The popliteal group are seldom involved in any disease except acute pyogenic infection from the foot.

The *inguinal group of glands* is a large group of great importance and may be divided into (*a*) the *femoral and deep inguinal glands*, which lie an inch or two below Poupart's ligament and along the upper part of the saphenous vein, receive all the lymph of the leg and foot and pass it on to the external iliac glands. These glands, therefore, are frequently involved by septic infections which commence in the foot or leg; they are not often infected by tuberculosis. The upper ones are close to the femoral vein and artery and also receive lymph from the superficial inguinal glands; the topmost glands of this group lie in the crural canal

(*b*) *The superficial inguinal glands* lie along and below the middle portion of Poupart's ligament. The outer members of this group receive vessels from the outer part of the thigh, the buttock and lower part of the back; the middle ones from the anterior abdominal wall as far up as the umbilicus, and the inner ones from the perineum, the anal canal, the vagina, the scrotum, the skin of the penis, the glans penis, and the urethra. In the female it is thought that certain lymphatics from the body of the uterus pass out along the round ligament to this group of glands. These glands drain into the deep inguinal and external iliac groups, while from the areas which they drain they are frequently involved by epithelioma and venereal infection, plague and filariasis.

The Head and Neck. There are many lymphatic glands in this neighbourhood, and though the majority of them really may be regarded as belonging to one big chain, it is customary to divide them for purposes of description into several groups.

In the head we find: The *preauricular* (*parotid*) *group* of glands lying just in front of the ear. They are beneath the parotid fascia and may be partly buried in the parotid gland, while they drain the lymph from the eyelids, conjunctiva, auricle, cheek, temporal and orbital regions. They are not infrequently involved in septic or tuberculous infections. Further back we find the *occipital glands* over the insertion of the trapezius and just below the superior curved line and draining the back part of the scalp; the *posterior auricular* (*mastoid*) *glands* lie on the mastoid process and drain the back of the auricle and the side of the head. These last groups of glands are frequently involved by sepsis usually due to pediculi capitis: the mastoid glands may break down and form an abscess closely resembling a mastoid abscess; such an abscess is, however, further back than one due to mastoid disease and does not push the auricle down in the same way. All these glands drain into the superficial cervical group.

In the neck there are the following groups: The *submental glands* just below the chin, in or near the midline and between the digastric muscles. They drain the lips, the front of the floor of the mouth and the tip of the tongue, so that they often become epitheliomatous. The *submaxillary glands* are a large group lying just below the lower border of the horizontal ramus of the mandible. Some of these are closely incorporated into the submaxillary salivary gland. They drain the lips and face, floor of the mouth, gums and teeth, front part of the tongue and anterior portion of the nose, while they discharge their lymph into the deep cervical glands. They are frequently invaded by epithelioma and septic or tuberculous infections. The *facial glands* are found at the point where the facial artery crosses the lower jaw and occasionally become tuberculous. The *superficial cervical group* is found chiefly in the posterior triangle, where they lie just under the skin and along the external jugular vein. They drain the scalp, *via* the occipital, postauricular and preauricular glands, and are frequently invaded by sepsis, as a result of septic conditions of the scalp and hair; the lymph passes from them into the deep cervical glands. The *deep cervical group* is usually regarded as consisting of two divisions, the superior and the inferior. The *superior deep cervical glands* lie beneath the sternomastoid and run down the internal jugular vein. Into these drain all the groups of glands above mentioned, while they also receive lymphatics from the pharynx, larynx, trachea, thyroid, inside of the nose and ear, antrum of Highmore and the inside of the skull. There is one special gland in this group which lies at the junction of the common facial and internal jugular veins which is known as the *tonsillar gland*, as it drains that structure. All these glands are very commonly invaded by epithelioma and by tuberculous or septic infection.

The *inferior deep cervical glands* (*supraclavicular*) are found just above the clavicle and behind and posterior to the sternomastoid. Into these the superior group drains, as do also the lower members of the superficial cervical glands. They also drain a portion of the skin of the chest, and some of the higher axillary glands, while certain lymphatics reach them directly from the breast tissue. They are sometimes found to be involved on the left side in carcinoma of the stomach.

The *retropharyngeal glands* are an important group which lie just to either side of the median line upon the prevertebral layer of cervical fascia. They drain the back wall of the pharynx, part of the posterior portion of the nose, and some of its accessory sinuses, the Eustachian tube and tympanum. The breaking down of these glands when infected by pyogenic organisms will give rise to a retropharyngeal abscess of one kind. (See Vol. II., Chapter VIII.)

Strictly speaking, such masses of lymphoid tissue as the tonsils, the thymus, the spleen, and such structures as the bone marrow, the cerebrospinal fluid and the fluids in the ear all may be regarded as part of the lymphatic system. These structures, however, will be considered elsewhere.

Wounds of the Thoracic Duct. This duct opens into the junction of the left internal jugular and subclavian veins. In many cases it opens into these vessels just to one or other side of their junction, and frequently by several channels. It is thus liable to be wounded in operations at the root of the neck such as phrenic avulsion and also by bullet wounds or stabs, while occasionally it has been torn by a fractured spine. When such a wound is produced, rhythmical jets of milky fluid, coinciding with respiration, may be seen to come out of the wounded duct, though this may not be noticed at the time of the operation, in which case later the dressings will be soaked with chyle. If the whole duct is cut across so that all the chyle escapes, exhaustion with great thirst and emaciation will occur and the patient may actually die. More commonly, however, only one of the several channels is wounded, and then no symptoms will be produced and the discharge of chyle usually will cease spontaneously. In other instances, and usually, the wound in the skin will heal by first intention without any chyle escaping, and the chyle may then collect beneath it in the form of a fluctuating swelling which will disappear spontaneously in a few weeks.

If the duct is wounded during operation and the wound noticed, it should be sutured if possible. Failing this, the branch of the duct should be ligatured and the wound carefully sutured together over it. In some instances it is possible to anastomose the wounded duct to one of the deep veins. Even if the main duct is ligatured no serious results are likely to follow, because of its various intrathoracic communications, and if the skin is accurately sutured no leakage will occur.

Rare instances have occurred where, as the result of an abdominal injury, the receptaculum chyli has been ruptured and the chyle escaped into either the peritoneum or actually into the ureter or kidney pelvis (chyluria); while in some cases the thoracic duct has become blocked either by the pressure of a tumour or a mass of glands, or as the result of scar tissue, and in this case it has happened that the receptaculum chyli has become distended and even ruptured, with the result that the chyle has escaped either into the peritoneum (chylous ascites) or into the pleura (chylo-thorax). This has occurred also as the result of a subcutaneous rupture of the duct when the thorax has been crushed (see Chapter XI., Vol. II.).

A few successful instances have been reported where in general peritonitis the thoracic duct has been opened and drained in the neck. It is thought that this has prevented the entrance of organisms or toxins to the blood stream.

Wounds of Lymphatic Vessels. The right lymphatic duct, which is much smaller than the thoracic duct, is occasionally wounded in similar circumstances, but this is of little importance. Any wound of the soft tissues divides lymphatic vessels, and if one of the larger lymph trunks happens to be wounded, lymph will be recognised occasionally in the discharge as a watery fluid. This will at times be sufficient to prevent the wound healing completely and give rise to a persistent lymphatic sinus (lymphorrhagia). These sinuses, however, do not persist for long, as new lymph channels are formed within a few weeks, and then the discharge ceases and the wound heals. They are seen chiefly after extensive removals of malignant glands, and especially in the groin.

Lymphatic Blockage. When excessive blocking of the lymphatics which drain a limb has occurred, the whole limb sometimes will become involved in a condition of lymphatic œdema. This is seen as the result of very extensive removal of glands by the surgeon, or when the subcutaneous lymphatic vessels are extensively blocked by carcinoma cells or by fibrosis and scar tissue, as occurs especially in old-standing gummatous infections, or which may be the result sometimes of past attacks of erysipelas or lymphatic infection. In some instances the condition gives rise to elephantiasis (see p. 311), so that any of the causes of this latter condition may give rise also to lymphatic œdema.

A limb affected by lymphatic œdema slowly becomes swollen, painful, tense and heavy. Pitting on pressure may be present at first, but in a short time the hardness of the tissues becomes such that no pitting can be produced. Elevation of the limb will relieve the swelling a little, but not so noticeably as in cases of ordinary venous œdema. After a time the skin undergoes overgrowth, and blebs and bullæ will form in it owing to the distension of the obstructed lymphatics; sometimes these will burst and give rise to lymphorrhœa and eczema. In addition to this, the fibrous connective tissues beneath are hypertrophied, changes which, when advanced, are characteristic of elephantiasis.

Treatment. If the condition is not due to extensive malignant permeation, and does not respond to elevation, massage, electrical treatment, etc., usually some diminution in size and improvement in the function of a limb can be obtained by means of the operation of **lymphangioplasty.** Here an attempt is made to drain the lymph away from the limb by forming artificial lymphatics by the insertion into the subcutaneous tissues of six or eight long thick silk threads which run right up the whole length of the limb from its lowest part and out for 4 or 5 inches on to the trunk on both the front and the back. They are introduced by means of a long blunt probe, which, in the case of each thread, is introduced by a nick in the skin at the lowest part of the limb, and pushed up into the subcutaneous tissues as far as it will go. Its point is then drawn out at its topmost limit through another nick in the skin, and the probe is then reinserted through the same nick in the skin and pushed up again as far as it will go. The process is repeated again and again until the silk thread is drawn right on to the trunk.

Another operative procedure intended to give rise to the formation of new lymphatic channels consists in the excision of long, narrow strips of skin, subcutaneous and deep fascia (right down to the underlying muscles) all down the whole length of the limb. The important structure to remove is the deep fascia, as doing this allows communication between the superficial and deep lymphatics. It is not always necessary to excise skin (Kondoléon's operation). In many cases amputation will be found to be necessary. In syphilitic cases the administration of iodides is often successful in very greatly reducing the œdema.

Acute Lymphangitis. This is an acute inflammation of the walls of the peripheral lymphatic vessels, due to their invasion by bacteria (nearly always the *Streptococcus pyogenes*), which are enabled to invade them through a primary septic lesion on the skin, usually either a little scratch, graze or septic blister The walls of the lymphatic vessels become red and thickened, while the tissues around them are also inflamed, and this inflammatory process runs rapidly up the lymphatic vessels to the nearest group of glands, which usually arrest it, though it occasionally leads to a general septicæmia. The lymph in the vessels becomes clotted, while the inflammation of the surrounding tissues sometimes may be very definitely marked and spread for some distance, when it is known as perilymphangitis. Suppuration not infrequently occurs either in and around the lymphatic vessels themselves, in which case a spreading cellulitis may be set up, or else in the nearest group of lymphatic glands, in which instance a large glandular abscess will form.

Cases of *gonorrhœal lymphangitis* on the dorsum of the penis are occasionally seen in gonorrhœal subjects.

Clinical Features. The wound from which the process spreads is usually a slight one ; it may show profuse signs of suppuration, but more commonly becomes dry, glazed and angry-looking. The condition sometimes arises as the result of eczema or of chronic ulceration of the skin. The onset of lymphangitis is sudden, with a marked rise of temperature to 102° or 103°, and often a rigor, rise of pulse rate and severe malaise, vomiting and headache. Running up from the causative wound there appear red streaks, which can be seen passing up towards the nearest lymphatic glands, which in their turn become enlarged and tender. These red streaks are tender and give rise to a sensation of burning pain ; they are the actual inflamed lymphatic vessels, and are of two kinds. If they are inflamed main lymphatic trunks, they are rounded and can be palpated while they remain distinct from each other (*tubular lymphangitis*). More commonly, however, many of the smaller lymphatic vessels are inflamed, and then the redness fuses into a ribbon-like blush, while the inflamed vessels cannot be palpated (*retiform lymphangitis*). Occasionally the symptoms of septicæmia will supervene, while where the attack is severe or has been repeated the vessels may become obliterated by fibrous scar tissue and give rise to lymphatic œdema or elephantiasis. It is by no means uncommon for suppuration to occur in the course of the inflamed lymphatics and give rise to a dusky brawny swelling, which soon softens and begins to fluctuate ; sometimes there will be a chain of these abscesses all up the vessels. In other cases, after three or four days, the nearest group of glands will break down and form a typical acute abscess. This disease hardly ever proves fatal except in the rare cases where, in debilitated people, septicæmia supervenes; it is, however, usually followed by a great feeling of asthenia and tiredness for a week or two after it has passed off.

Treatment. The causative wound must be treated and if necessary opened up to let out pus; in most cases, however, it will be sufficient to paint it with iodine and apply hot dressings. The limb itself is kept at rest, while fomentations and soaking in hot baths will be found of value. Passive hyperæmia produced by Bier's bandage or Klapp's suction bells is often useful.

If abscesses form they must be opened, while the patient's general condition is improved as far as possible by administration of sulphanilamide drugs and attention to the bowels, light diet and tonics; alcohol, sulphuric acid or quinine by the mouth are possibly beneficial. After the acute symptoms have passed off, massage and firm bandaging will help to disperse any œdema that may be present.

Chronic Lymphangitis. This is sometimes the sequel of an acute attack, but is more commonly found to occur as the direct result of syphilitic or tuberculous (and rarely glanders) infection of the lymphatic vessels. It gives rise to thickening, fibrosis and blocking of the vessels.

Tuberculous Lymphangitis. Although in a great many cases the bacillus of tuberculosis is carried about the body by means of the lymphatic vessels, the exceedingly common condition of tuberculous glands being produced in this way, yet the vessels themselves are not very often affected by the disease. When this does occur, the lymphatic vessels above a primary tuberculous focus, usually on the hand, become thickened and nodular, these nodules being at first firm and tough but gradually softening and breaking down to form abscesses and ulcers, while after a time the nearest group of glands above will become infected. This condition is not uncommon in the mesentery.

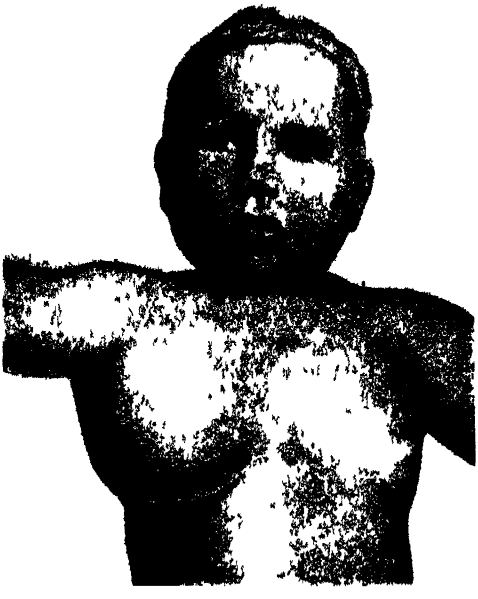


FIG. 173. Cystic hygroma of the axilla.

The *treatment* for this condition consists in the excision, if possible, of the primary focus, the lymphatic vessels running up from it with their secondary abscesses and the first group of glands above, all in one mass.

Occasionally an overgrowth of the tissues due to a combination of thickening and dilatation of lymphatic vessels is seen in the lips of tuberculous children, who have had constant sores and cracks around their mouth.

Syphilitic Lymphangitis. This is only seen in the dorsal lymphatics of the penis in cases of primary syphilis, the lymphatic vessels then becoming hard and cord-like along the back of the organ. The inguinal glands soon will become enlarged and shot-like, while there may be a certain amount of solid œdema of the foreskin. The treatment of this condition is that of syphilis in general.

There is no doubt that in cases of carcinoma the lymphatic vessels form one of the chief means by which the disease spreads over the body (see p. 184). As the result of the lymphatic vessels becoming permeated with carcinoma cells, a reactive fibrosis is set up in the surrounding tissues which squeezes and compresses the vessel with its contained malignant cells, so that these cells die and the lymphatic vessel becomes converted into solid fibrous cord and remains permanently blocked.

Lymphangiectasis. This is a condition in which lymphatics, normally present, become grossly dilated and distended, while they may or may not preserve their continuity with the ordinary lymphatic circulation. The condition is sometimes congenital, in which case it is due to some alteration in the lymphatics during development or to intra-uterine inflammation, but more often it is acquired, as the result of any condition which causes blocking of lymphatic trunks.

Diffuse lymphatic cystic dilatations are seen in the neck, axilla and groin in children. They form soft and flaccid swellings, and are known as **Cystic Hygromata.** (See Chapter X., Vol. II.)

In the tongue and lips it occurs as a congenital condition known as **macroglossia** and **macro-cheilia.** These are congenital and great enlargements of the tongue and lip due to blocking of the lymphatic vessels and subsequent overgrowth of the connective tissues.

A **chylous hydrocele** is sometimes seen in which the tunica vaginalis, and in some cases the lymphatic spaces of the cord are full of chyle, as the result of some obscure lymphatic obstruction. A diffuse dilatation of the lymphatics of the spermatic cord is sometimes seen, and is known as a diffuse hydrocele of the cord. Another important type of lymphangiectasis is that due to filaria.

Filarial disease is due to the presence of filaria in the lymphatics, and is seen in persons who have lived in the tropics, chiefly in the groin and scrotum, where it gives rise to a soft boggy swelling, painless, and often as large as an orange, which can sometimes be made partly to disappear on pressure or when the patient lies down. If this condition progresses far it gradually passes into the disease known as Elephantiasis Arabum (see p. 312). The patient will get feverish attacks, with pain in the swelling, at regular intervals, the swelling becoming bigger and spreading as the result of each attack, so that in time it may come to resemble a lipoma of the groin, a hernia, or a saphenous varix. When limited to the groin or scrotum, the swelling may be excised; it is, however, liable to recur again later.

Elephantiasis. This is an intense overgrowth of the skin and subcutaneous tissues which occurs as the result of long-continued lymphatic obstruction. The condition usually affects the legs, groins, penis and scrotum, spermatic cord and vulva; in some cases the breast, arms and face have been involved. The tissues affected are found to pass into a state in which they are firm and brawny from solid lymphatic œdema which does not pit on pressure (see p. 308), while in addition and as a result there is enormous overgrowth and thickening of all the fibrous subcutaneous tissues and of the skin itself, which becomes coarse, overgrown and warty; on the surface of the skin there frequently will be seen vesicles containing a watery fluid, which are liable to burst and give rise to a troublesome lymphorrhœa; the thick, devitalised skin is specially liable to sepsis, chronic ulceration and lymphangitis. There are two main types of elephantiasis:—

(*a*) *The filarial type,* otherwise known as **Elephantiasis Arabum.** This is seen especially in Barbados, the West Indies, South America and Japan. It rarely affects any part except the legs, penis, scrotum and vulva, while the parts occasionally attain enormous size, the penis and scrotum sometimes reaching down and resting on the ground when the patient is sitting. There is no pitting on pressure and little diminution in size on elevation of the part affected. In Fiji it is sometimes seen to give rise to a local overgrowth of the skin, which hangs down like a pear-shaped tumour.

The disease commences with fever and signs suggestive of lymphangitis, and it is not until a number of such attacks have occurred and passed off that the lymphatics appear to become finally blocked and the swelling of the skin and subcutaneous tissues to commence. The disease is due to the presence the *filaria sanguinis hominis* in the lymphatics, though in some instances it is actually due to a streptococcal infection predisposed to and set up by the pressure of filaria. The intermediate stage of the filaria is passed in the body of a mosquito, from which the parasites are discharged into water and thus enter the human stomach. In the stomach the worm is set free, finding its way through the gastric wall into the lymphatics, especially those of the groin. The female worms, when in the lymphatics, set free countless embryonic filaria, some of which remain in the lymphatic vessels and further obstruct them, and others pass into the blood stream, where they are to be seen usually at night (*filaria nocturna*), or sometimes during the day in cases of

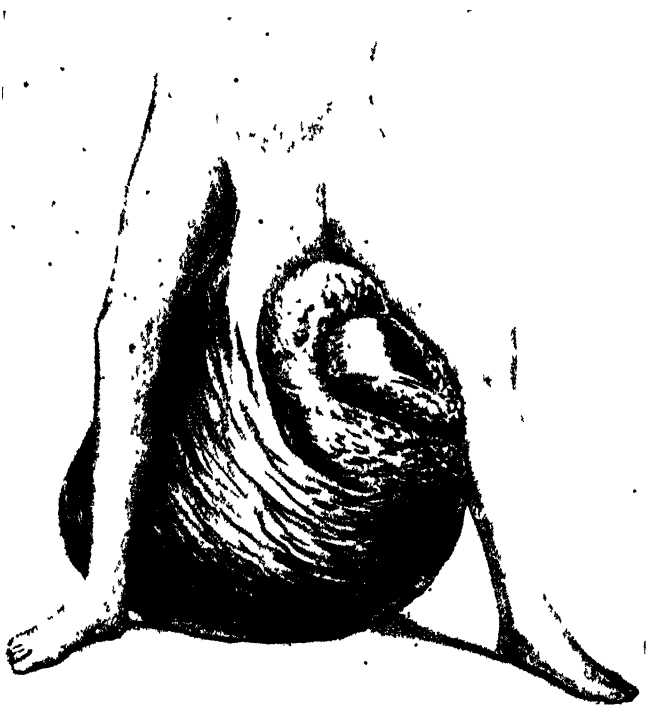


FIG 174. Advanced elephantiasis of the penis and scrotum due to filariasis.

filaria diurna. If they are found in the blood at all times the condition is called *filaria perstans.*

(*b*) *The non-filarial type,* which may be due to the blockage of lymphatic vessels or glands by carcinoma or infection, the operative removal of glands or lymphatic vessels or repeated attacks of lymphangitis, while it is sometimes associated with an old-standing varicose ulcer. In many cases of apparently unknown origin it is due to previous attacks of streptococcal infection accompanied or followed by venous and lymphatic stasis (Milroy's disease). A similar condition sometimes occurs, especially in women, as the result of lupus upon the foot or toes. The lymphatics up the leg become blocked by tuberculous invasion, with the result that the skin below becomes overgrown and thickened, and is sometimes covered with tuberculous sinuses and granulation tissue (**Lupus Elephantiasis**).

In other cases milder degrees of elephantiasis have occurred as the result of long-continued venous obstruction, while congenital cases have been described which are thought to be due to the constriction of the limb in utero by amniotic bands.

There are other forms of elephantiasis which are in no way connected with lymphatic obstruction. **Elephantiasis neuromatosa** is a condition in which the whole limb becomes swollen and overgrown as the result of a diffuse fibro-neuromatosis in the subcutaneous tissues, which usually begins early in life, while **Elephantiasis Græcorum** is the result of leprosy in the face, the skin of which becomes overgrown by large nodular masses.

Treatment. The treatment of elephantiasis due to lymphatic obstruction is most unsatisfactory. It is occasionally possible to remove the parent filarial worms, of which only a few are generally present, if they can be localised, while to relieve the lymphatic obstruction elevation of the limb, firm pressure and massage may be tried. Finally various operative measures have been attempted, though before any of these can be undertaken the skin, which is frequently dirty and septic, must be cleansed thoroughly and sterilised. Attempts have been made to find a dilated lymph trunk and implant it into the side of a vein such as the internal saphenous, while Sampson Handley's operation of lymphangioplasty has also been employed in this condition. The results of this have been considerably better in the upper than in the lower limb. (See also Kondoléon's operation (p. 309.).) In some cases amputation of a limb will be the best remedy, while in other instances a radical operation can be performed and a large portion of the overgrown scrotum excised, a plastic operation being performed to repair it (see also p. 309).

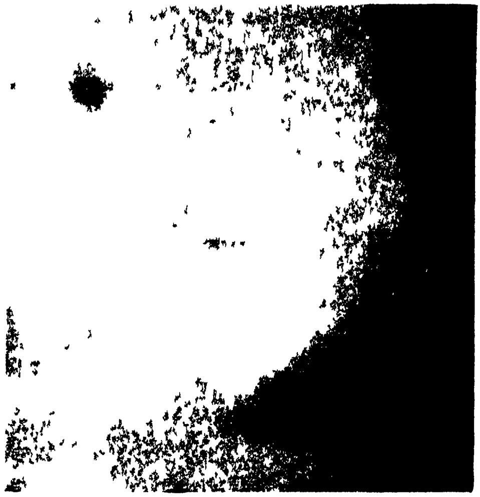


FIG. 175. A soft lymphangioma of the abdominal wall and groin with lymphatic vesicles over it.

Lymphangioma. This is a tumour formation consisting of newly-formed lymphatic vessels which is described on p. 210. There are two main types, the capillary lymphangioma and the cavernous lymphangioma. A cystic lymphangioma, otherwise known as a lymphatic cyst or cystic hygroma, is also one variety of this condition, and this will be found described on p. 210.

DISEASES OF LYMPHATIC GLANDS

Inflammation of lymphatic glands (lymphadenitis) may be acute, in which case it is due to ordinary pyogenic organisms, or chronic, the latter form being due either to tuberculosis, syphilis, or pyogenic organisms of very low virulence.

Acute Lymphadenitis. Acute inflammation of the lymphatic glands results from the presence in the glands of bacteria (and possibly of toxins or other irritants), which are brought to the glands by the lymph vessels which drain into them from the periphery. The causative organisms are most commonly streptococci or staphylococci, and the peripheral infected lesions from which these organisms have reached the lymphatic vessels usually can be discovered in the drainage area of the glands concerned. The vessels conveying the organisms to the gland usually show no signs of disease themselves, and the glands can be looked upon as filters which extract noxious substances from the vessels reaching them, in the process of doing which they may themselves become inflamed and infected and even suppurate. In many cases there will be a history of injury in the neighbourhood of the glands affected, and it is possible that this may be a predisposing factor or that organisms which have previously been lying latent in the glands become active as the result of a blow or other trauma. It will be noticed that the peripheral infections, which are particularly liable to give rise to adenitis, are not as a rule very serious ones and tend to be of a superficial type. Thus acute infection of the lymphatic glands is not usually seen in severe cellulitis, gangrene or deep abscess formation, but it is frequent in connection with minor infections of the throat and tonsils. There is a great tendency for infected lymphatic glands to soften and suppurate, while in all cases there is a certain amount of inflammation of the connective tissues around the gland, with the result that the glands tend to become matted, fixed to one another and to the surrounding tissues. In severe cases the inflammation spreads outside the glands and may give rise to a diffuse cellulitis. Resolution usually occurs completely in the cases which do not suppurate, although in some instances the gland will lose its lymphoid tissue and become fibrosed and persist indefinitely as a hard painless swelling. Organisms are particularly liable to be latent in lymphatic glands for prolonged periods, and then may at a later date suddenly become active again.

Clinical Features. These will vary greatly according to the severity and virulence of the infection. There may be a characteristic lymphangitis, but this is frequently absent, while the signs of infection in the glands may occur soon after the commencement of the causative lesion or sometimes not until later, when the primary lesion has more or less disappeared. Such a lymphadenitis commences by the glands rapidly becoming enlarged and tender, while they soon become fixed and matted to one another, so that the tissues round become brawny. If they are near the surface the skin over them may become hot, red and œdematous. In many cases the condition is mild and rapidly disappears again. This is seen especially in the neck in association with sore throats and tonsillitis. In other instances the condition is more persistent and more likely either to suppurate or to pass into a subacute stage instead of clearing up. This is seen especially in association with adenoids, enlarged tonsils, septic teeth and chronic otitis media. Similar subacute enlargements of the glands (without the tendency to suppuration) are seen in the axilla as the result of chronic mastitis and sometimes in the groin in connection with balanitis. Other cases are much more acute, and suppuration rapidly sets in, with the result that an abscess forms, this probably being largely due to the circulation through the gland becoming obstructed. When this occurs the pain, redness and tenderness are more marked, while the matting of the surrounding tissues is increased. The temperature will be raised, with marked malaise, and softening will occur in the centre of the mass of glands and finally fluctuation be obtainable. These cases are frequently due to streptococci.

Thus in the axillary glands suppuration will occur often as the result of infected wounds of the hands and fingers, axillary boils, and septic conditions of the breast. An **axillary abscess** will form, which may be quite superficial, but is more commonly under the strong deep axillary fascia ; this will retain the pus, so that it gives rise to a very large collection lying under the pectoral muscles, filling the axilla right up to its apex and even extending up into the neck. Such an abscess is best opened by Hilton's method, the incision being made from above downwards, midway between the two axillary folds and running down the chest wall parallel to the long thoracic artery.

In the groin such suppuration is often more chronic, and the pus will remain confined sometimes within the gland capsule for a considerable time. Such a suppuration will give rise to an **inguinal abscess,** which is best opened by a vertical incision parallel to the main vessels, as this incision will gape open and drain better than a transverse one.

In the neck the condition may be very serious, as it is liable to give rise to a rapidly-spreading cellulitis, especially when arising as the result of streptococcal infections of the deep cervical glands. These **cervical abscesses** are especially common in children as the result of eczema or pediculosis of the scalp, impetigo, chronic otitis media, and septic conditions of the lips, teeth, mouth and throat. In opening them Hilton's method must be employed, while the incision is best made transversely across the platysma myoides.

Treatment. The primary focus from which the infection has arisen should first be treated and if possible eradicated ; in the less acute conditions this will result in the glands settling down completely. This recovery of the glands will be assisted by antiphlogistin, hot dressings, Klapp's suction bell and the administration of calomel, followed by iron and quinine. As soon as suppuration sets in and an abscess appears to be forming, it must be opened and drained. This procedure may be very urgent at times in the neck. The opening of such an abscess must be followed by antiseptic dressings for the wound. If it is decided still to apply hot fomentations, an antiseptic ointment must be incorporated with them, such as unguentum hydrargi nitrati dil., to prevent the organisms infecting the skin round.

Chronic Lymphadenitis. This occurs as the result of infections of three different types : chronic sepsis, syphilis, and tuberculosis. The latter is by far the commonest.

(*a*) **Chronic septic lymphadenitis (simple lymphadenitis)** is not very uncommon. It is most commonly seen in the posterior triangle of the neck, where, in children with chronic septic conditions of the scalp, chains of hard, painless, fixed and matted medium-sized glands are felt ; it also occurs in the anterior triangles in association with adenoids, carious teeth, etc. In some cases these glands result from previous acute attacks of lymphadenitis but more commonly they are painless and chronic from the first. Small hard glands of this kind are frequently seen in the groins, and here, though they are sometimes due to chronic infection, it is possible that they are due to blows, strains, minor injuries or excessive muscular exercise, which will result in the obstruction of the lymphatic flow either by compression or rupture of the lymphatic vessels leading from the glands. Such a condition of chronic enlargement of the glands very probably predisposes them to tuberculous infection.

The *treatment* consists in removing the peripheral source of infection or irritation and attending to the general health. The glands then usually will disappear ; if they do not they are probably tuberculous.

(*b*) **Syphilitic Lymphadenitis.** This occurs in all three stages of the disease. In the primary stage the lymphatic glands draining the area in which the chancre is, become painlessly enlarged, remaining firm, mobile and discrete. In the groin, in the case of a genital chancre, these glands remain moderately large, firm and shotty (see p. 111), but in the case of extra-genital chancres the enlargement may be much more marked and the glands will become soft and fleshy, forming great discrete masses almost like bunches of grapes. This is especially found to be the case in the axilla in the presence of a digital chancre.

In secondary syphilis the glands all over the body also become enlarged, firm, shotty and discrete. This is seen especially along the back of the neck and in the epitrochlear glands (see p. 113).

In tertiary syphilis the glands are very rarely affected, gummatous disease being very uncommon. Should this occur the gland rapidly increases in size, becoming big, soft and elastic and fixed to the surrounding tissues. After a time it will break down and the skin over it ulcerate, so that the slough is discharged and a typical gummatous ulcer formed. It must not be forgotten that many of the lesions of tertiary syphilis may become septic and thereby give rise to septic infection of the glands in their neighbourhood, but this is not a true syphilitic lymphadenitis.

The treatment of all these conditions is that of syphilis in general (see p. 121).

(*c*) **Tuberculous Lymphadenitis.** Tuberculous disease of lymphatic glands is very common indeed. It is especially seen in children or in young persons whose general condition is poor, above all those whose food and surroundings are unsatisfactory and unhealthy. It is found most commonly in the cervical glands, and here there is usually a local source of infection in the form of a dirty scalp, carious teeth and enlarged tonsils or adenoids, by means of which the glands probably become infected first of all with chronic sepsis and later with tuberculosis. In the case of the glands in the neck, groin and axilla the infection is usually with the human type of bacillus, but in the abdominal and mesenteric glands the bovine type is frequently found. The organisms reach the glands *via* the lymph vessels, into which they probably obtain access through some breach of surface or possibly through an intact mucous membrane. Once in the body, however (and possibly lying latent there), it is not unlikely that they will pass to other glands *via* the blood stream. Any lymphoid tissue in the body may become infected by tuberculous organisms ; it is, however, especially common for this to occur in the cervical and mediastinal glands, less common in the mesenteric glands, fairly common in the axillary glands and rare in the inguinal glands.

When a gland becomes infected with tubercle, in the early stages it undergoes a fleshy enlargement. It may become many times its natural size, is of a pinkish colour, normal in appearance and consistence, and at first freely movable and non-adherent to surrounding structures, as there is, in the early stages, no periadenitis. At this stage, microscopically, it will be seen that the fibrous structures of the gland are overgrown, the lymphoid cells greatly increased and endothelioid cells proliferating, while the characteristic microscopic tubercles will be present with their giant and epithelioid cells. Possibly the bacilli also may be demonstrated. After a time caseation commences, and this starts in the form of minute grey foci throughout the whole gland, which enlarge, fuse and finally convert the greater part of the gland into a caseous mass, surrounded by a thickened fibrous capsule, fibrosis always being marked around any tuberculous lesion which has been present for some little time. At this stage, or even before it, periadenitis commences, so that the gland, or what is left of it, becomes adherent to other glands and surrounding tissues, both fasciæ, muscles, veins and arteries. The process of caseation may take many months before it becomes complete, and when once established may remain unaltered for a long time. Occasionally, even when caseation is present, the condition may become cured slowly by the gland fibrosing and shrinking till it becomes a small, hard, adherent nodule.

In many cases calcification occurs as the end result, this latter process being especially seen in the abdominal and mediastinal glands. Most frequently, however, sooner or later the caseous material liquefies and suppuration sets in, this process consisting either—

(*a*) in a simple liquefication of the caseous contents to form a tuberculous cold abscess, or :

(*b*) in a superadded infection with septic organisms giving rise to a more acute and frankly pyogenic suppuration.

Either of these processes may occur with or without the process of caseation preceding them. If the suppuration is due to a pyogenic mixed infection, it is moderately acute and resembles that already described on p. 69, but in the more usual cases, where it is an unmixed tuberculous suppuration, the process is chronic, more or less painless, and unaccompanied by any fever or malaise. Foci of pus appear throughout the gland and coalesce to form abscess cavities, the gland ultimately becoming more or less completely destroyed and being converted into a large, irregular abscess cavity, the walls of which are composed of a rough, pyogenic membrane limited by a firm fibrous capsule, adherent to which there still may be found portions of undestroyed gland tissue, the whole forming a tuberculous cold abscess (see p. 318). With the onset of suppuration, periadenitis is certain to be marked, so that the glands then, if not before, become firmly adherent to one another and to surrounding tissues. If the abscess is near the skin the latter will become reddened and thinned slowly, ultimately giving way, so that the abscess bursts and the pus and caseous material escape. When this occurs the result will be either a characteristic tuberculous ulceration of the skin—that is, a shallow ulcer with thin blue undermined edges, pale flabby granulations at its base and a watery discharge ; or else, instead of an ulcer, a sinus will form running down to the remains of the glandular tissue below, persisting for years with a continual discharge of pus or caseous material and leading to a great deal of fibrosis and scarring. Should it finally heal on its own the scar will be puckered, depressed and often keloidal (see p. 24). At times large vessels are ulcerated into by the process, so that severe hæmorrhage occurs, but this is less likely than in septic infections, while many important structures such as muscles, vessels and nerves will become matted together and fixed to the glands. At any stage in the disease the process may become arrested, while great variations will be found in the rapidity of enlargement and the rate of progress. The onset of suppuration and liquefaction is sometimes shown by slight pain and tenderness, increased fixity of the gland, by its becoming more spherical in shape, whilst finally it softens and fluctuation will be obtained.

The differentiation of this type of glandular enlargement from lymphadenoma, lymphosarcoma and leucocythæmia is sometimes difficult. The history and age of the patient will help, whilst any signs of suppuration, liquefaction and softening are strongly suggestive of tuberculosis. The glands of lymphadenoma are distributed all over the body, they do not become adherent nor do they break down, though in lymphosarcoma they may undergo cystic degeneration. Tuberculous glands show a marked tendency to become matted together and fixed to the surrounding tissues, but they roughly retain their ovoid shape; it must be remembered that there is a type of tuberculous gland, known as the lymphadenoid type, which will remain discrete for long periods; lymphosarcoma becomes even more fixed but infiltrates the tissues and loses its round shape, while it increases in size much more steadily and rapidly. There are none of the blood changes of leucocythæmia in tuberculous glands. Calcification (which will show a shadow in an X-ray plate) only occurs in tuberculous cases. Secondary malignant glands sometimes will cause difficulty, but they are far harder and become more fixed to surrounding structures, while the primary growth from which they have arisen can usually be discovered. If in doubt one of the glands must be removed and examined microscopically.

The prognosis of tuberculous disease of glands is in general good. It is not dangerous to life, and if properly treated should be recovered from, though such patients are liable to develop tuberculosis elsewhere later on.

A **cold abscess** due to breaking down of tuberculous glands has to be distinguished from one due to other causes, such as disease of the bones or spine, and also from various types of cysts. This can be done usually by the fact that the wall of an abscess due to a breaking-down gland contains a certain amount of solid material in it which is the remains of the glandular tissue. This is not found in abscesses from bones or in cysts.

In rare instances tuberculous glands are the starting point of a generalised miliary tuberculosis, and this is sometimes seen after operative interference.

Treatment. There are two distinct lines of treatment which may be adopted, consisting broadly of conservative measures or operative removal. Conservative measures always should be tried when the condition is in its early stages and provided there are no signs of the glands breaking down to form an abscess. They consist in measures to improve the general health, such as good diet and tonics, above all cod-liver oil and iron, and an open fresh air life, especially on mountains or by the sea; Margate is regarded as specially suitable for such cases. All sources of irritation, such as sepsis from bad teeth or tonsils, should be removed and the parts rested as far as possible. Exposure to real or artificial sunlight is beneficial, while small doses of tuberculin or exposure to X-rays sometimes will produce a cure. These latter methods, however, if they fail (and they often do), will render any subsequent operation far more difficult. On the other hand, if the disease is spreading to other glands, if it does not soon improve under conservative measures, and above all if the glands begin to soften and break down, their complete removal by operation is undoubtedly the wisest course, and some authorities advise this in all cases. This should be done, if possible, before the glands break down, as once liquefaction has occurred complete removal is not likely to be possible; in most cases operation will then have to consist in the treatment of the cold abscesses formed (see p. 107), and probably will take the form of incision and curetting, which is liable to be followed by sinus formation. If the skin is already broken and ulceration has occurred, the ulcer may be curetted and the diseased skin cut away as far as possible, while the cavities left are packed with iodoform. It must be remembered that general constitutional treatment is just as important after an operation as before it—probably even more so.

Tuberculous Cervical Glands. This is by far the commonest situation of the disease, where it is usually seen in children and young people, is frequently bilateral and may involve any of the glands, beneath, behind or in front of the sternomastoid. Those in the posterior triangle are far less commonly affected, while it is usually found that enlarged tonsils, adenoids or carious teeth are present; that is, the tuberculous infection supervenes only on glands already the seat of chronic septic infection. At times only one gland is affected, and this is usually just below the angle of the lower jaw, but when it spreads to other glands the greater number of the deep cervical group ultimately will become enlarged. In other cases the preauricular gland or the posterior auricular ones are those first implicated. When the deep cervical glands become involved they exhibit a special tendency to become adherent to the internal jugular vein, while when they break down and suppurate a mixed infection is more likely to occur than elsewhere in the body as pyogenic organisms may be introduced from the throat. Glandular cold abscesses in this situation are common, and inasmuch as the glands lie under the firm deep cervical fascia it sometimes happens that the pus finds its way out through this fascia through a small opening, and collects under the skin, while the gland from which it originated lies beneath the fascia, so that the abscess cavity formed will be hour-glass-shaped; the presence of the deeper portion of the abscess, with the remainder of the gland tissue, must then not be forgotten (*collar stud abscess*).

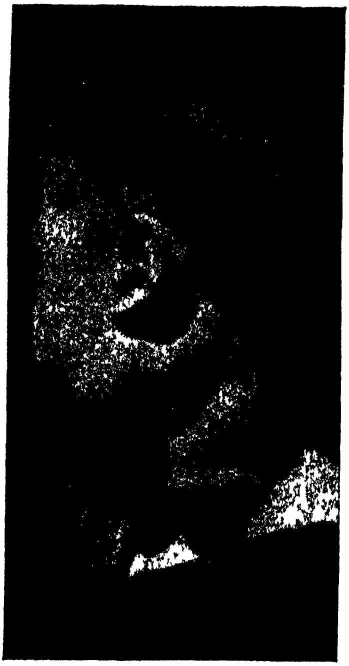


FIG. 176. Tuberculous lymphadenitis.

Treatment. In all cases local septic foci, teeth or tonsils, must be removed promptly and efficiently, and good hygiene ensured. This often suffices to ensure the glands settling, but the process of resolution can be aided and hastened by judicious X-ray or sunlight treatment. Should this fail, however, then surgery should be resorted to without waiting for the glands to break down. In the neck the importance of an invisible scar must be remembered, as also must be the fact that the scar of an operation will be less noticeable than that following the bursting of an abscess followed by curetting.

Thus operation should be undertaken before there is any chance of abscess formation, and it should consist in complete extirpation of all the glands affected. This may be a difficult and elaborate procedure, and must be done through a skin incision sufficiently large to give access to the whole field infected. This incision will depend upon the situation of the glands, and it should if possible be made across the neck or in the natural creases of the skin. A curved incision below the jaw, and similar to that used for tying the lingual artery, is a favourite one, while a long incision along the border of the sternomastoid muscle will be found useful. Another one suitable for glands lower down runs parallel to and immediately above the clavicle. If the glands are at all extensive, more than one of the above incisions will be required, while it will be necessary to retract the sternomastoid either backwards or forwards or sometimes even to divide it, this must be done below the point where the spinal accessory nerve enters it. Special care must be taken of the spinal accessory, vagus and phrenic nerves, the facial nerve and its inframandibular branch and the hypoglossal nerve, while the carotid arteries may need exposure. The muscles should be preserved as far as possible, but the common facial and the external or internal jugular veins may need ligaturing and resecting. Muscles, if necessary, may be divided and sutured together afterwards. An important principle which will be found to render the dissection easier is to drag upon the mass of glands with a pair of forceps, so that all the structures are rendered tense and the important structures of the neck can then be dissected off the mass of glands. It must be remembered that it always will be found that the diseased glands are far more numerous and extensive and far deeper than appears to be the case on external examination.

When abscesses have formed in the neck, a deeper portion communicating with the superficial part through a small opening in the cervical fascia must be sought for. It is not wise to attempt to dissect out glands when abscesses are present; the abscess should be opened, its walls curetted and all surrounding glandular tissue curetted away as completely as possible, and the wound closed without drainage. In many cases a sinus will form, and then a subsequent operation will be necessary in order to dissect out any remaining glandular tissue and cause the sinus to close.

Tuberculous Axillary Glands. These are moderately common and are usually infected by an extension from glands in the neck or from the ribs or a tuberculous breast. Occasionally the source of infection is a wound in the hand or finger. The glands each become very large, and they later fuse together to form a large mass which fills the axilla, bulges down towards the arm and pushes the pectoral muscles forwards. Suppuration is common. In this case there should be no resort to conservative measures at all, but the glands should be completely removed as soon as possible. This is best done by an incision along the lower border of the pectoralis major, and it will be found usually that owing to the presence of the loose axillary fat, the removal of the glands and the surrounding fascia is remarkably easy.

Tuberculous Inguinal Glands. The disease here is rare and usually affects either the femoral or the external iliac glands. Possibly in some cases it may be the result of the infection of wounds on the toes. The glands tend to become especially matted and adherent both to themselves and surrounding structures, while suppuration and later ulceration of the skin nearly always occur. The condition is sometimes mistaken for glandular enlargement associated with venereal disease. In the case of iliac glands, atrophy of the testicle sometimes follows, through implication of the spermatic vessels.

The treatment consists in complete excision of the glands, and if necessary of the overlying skin. This may be a most troublesome and difficult operation, especially when the iliac glands are involved and are very adherent. It should be remembered that septic infection and suppuration, sometimes with sloughing of the skin, is especially liable to follow upon operations for removal of glands in the groin.

Tuberculosis of the abdominal and thoracic glands will be described elsewhere (see Chapters XI., XIII. and XVI., Vol. II.).

TUMOURS OF LYMPHATIC GLANDS

Both primary and secondary tumours occur in lymphatic glands and lymphoid tissue, the latter being by far the commonest. Nearly all tumours of the lymphatic system are malignant.

Primary Tumours. An overgrowth of what appears to be normal lymphoid tissue is sometimes seen in various parts of the body, and then may be given the name of **lymphoma.** This is seen sometimes in lymphatic glands, and especially in the tonsil, the pharyngeal lymphoid tissue, and the lymphoid tissue in the intestinal canal. It is not malignant and of no pathological significance.

Lymphosarcoma. This condition may be regarded really as a small round-celled sarcoma arising in lymphoid tissue. It is thus most commonly seen in the glands of the neck or groin, the thymus, tonsil, mediastinum and the Peyer's patches of the intestine. It has a structure closely resembling lymphadenoid tissue and consisting of round cells set in a reticulated stroma, and it differs from the ordinary type of round-celled sarcoma in that this fibrous stroma is more marked and definite. Though microscopically there is no marked evidence of this malignancy, clinically lymphosarcomata are found to be highly malignant. Thus the growth occurs as a rapidly growing tumour, which soon invades and destroys surrounding tissues. If commencing in a gland, one big gland will be found at first with smaller glands around it, but the growth soon breaks through the capsule of the gland, which loses its shape and becomes fixed to the surrounding tissues. The tumour is at first firm and painless ; later on it becomes very big and gets tender, softer, and may press upon or infiltrate any important surrounding structures, while neighbouring glands will rapidly become involved. The skin is at first unaltered, but later becomes shiny, while big blue veins will be seen under it ; after a time it becomes infiltrated and gives way, so that ulceration and fungation of the growth occur, as is the case with other malignant tumours. Secondary deposits all over the body soon set in and death is not long delayed. The disease may occur at any age, but is rather more common in young people. The prognosis is very bad indeed, and the only treatment consists in the earliest possible removal of the growth if practicable. This should be followed by treatment with radium or X-rays, but in many cases excision is impossible, and then treatment by radiation is the only course. Radiation often will cause the growth to decrease in size or even to disappear, but recrudescence followed by death nearly always occurs later on after a short interval. Lead injections as advocated by Blair Bell are of benefit in some cases.

Secondary Tumours. Secondary carcinoma of lymphatic glands is a very common condition, and is one of the commonest causes of glandular enlargement. The microscopic type of growth will be columnar, spheroidal or squamous according to the type of the primary growth, the last being by far the commonest. Malignant glands of this kind give rise to rapidly growing tumours, stony hard from the first ; the glands soon become fixed both to themselves and to all the surrounding structures. Fixity sets in very rapidly, as the carcinoma cells lodge first in the capsule of the gland, where the vessels enter it, and tend often to invade the gland less rapidly than the surrounding fat and fascia. These glands are painless at first, but soon implicate and invade the surrounding structures to a sufficient degree to give rise to severe pain and interference with function. Such a glandular mass may be larger than the primary growth from which it originates. The mass after a time will soften and liquefy, while the skin will become adherent and invaded, finally giving way so that ulceration followed by fungation will occur. It must be remembered that in many cases the primary growth is upon a free surface, and is, therefore, in an exceedingly septic condition; and thus a considerable amount of the glandular involvement may be the result of infection rather than of invasion by growth. A mass of this kind which is obviously malignant should never be diagnosed as secondary carcinomatous glands unless the primary growth can be discovered, as it is quite possible that it is due to lymphosarcoma, ordinary sarcoma, and, in the neck, to such rare conditions as branchial carcinoma or tumour of the carotid body (Chapter X., Vol. II.). There is also evidence that in rare instances a small primary malignant growth may disappear spontaneously, while the mass of glands secondary to it persists and increases.

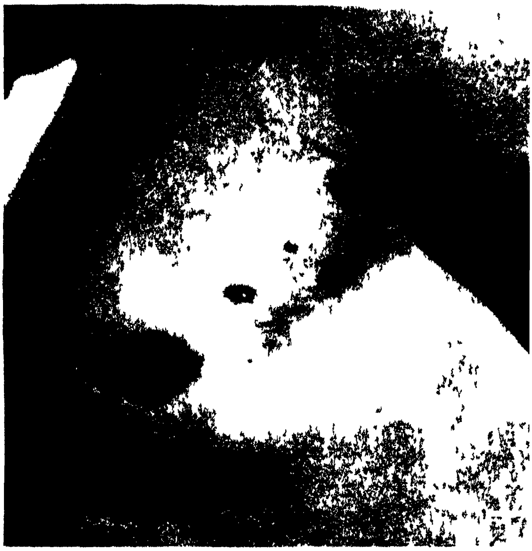


FIG. 177. Fungating malignant axillary glands secondary to an advanced spheroidal carcinoma of the breast in a lady of forty-nine.

In the neck secondary carcinomatous glands are especially common; here they will be the result of an epithelioma of the lip, tongue, cheek, fauces, tonsil, pharynx, larynx. œsophagus, palate, nose, ear, scalp or skin; on the left side they may also be secondary to a carcinoma of the stomach. It should be remembered that in the neck any tumour which is bossy or appears to consist of several separate masses fused together is almost certainly a mass of glands enlarged from one cause or another. The supraclavicular glands may become invaded secondarily to a carcinoma of the breast. (For the treatment of secondary carcinomatous glands of the neck, see Chapter X., Vol. II.)

Secondary malignant glands of the groin are common from epithelioma of the penis, scrotum, vulva, anus, and of the skin of the leg and foot. The axillary glands usually become malignant from carcinoma of the breast or epithelioma of the skin of the hand and arm. The thoracic and abdominal glands are frequently invaded by secondary carcinoma when the primary disease is in any of the organs within their drainage areas.

Melanotic carcinoma of the glands is frequently seen as the result of a primary growth on the skin. Such glands have the same characteristics as secondary carcinomatous glands, except that they are less hard, grow even more rapidly, and may be black and pigmented on section. The primary growth sometimes will be a tiny black speck even when the glands have already become quite big.

Treatment. The treatment of secondary carcinomatous glands consists in their complete removal, and this is usually undertaken during the operation for removal of the primary growth. Radiation gives disappointing results in glandular metastases and should be used only in conjunction with surgery.

Secondary sarcoma of lymphatic glands is very uncommon in connection with the ordinary sarcomata of bones and muscles. It is, however, frequently seen in lymphosarcoma, sarcoma of the thyroid and the so-called sarcoma of the testicle (see Chapter XXI., Vol. II.). There is no treatment, save X-rays and radium, for secondary sarcomatous glands.

LYMPHADENOMA (HODGKIN'S DISEASE)

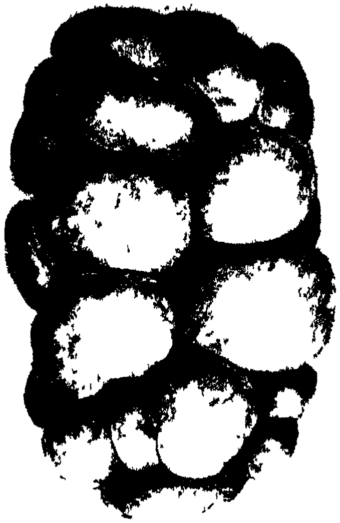


FIG. 178. A mass of discrete lymphadenomatous glands.

This is a somewhat rare disease, the pathology of which is unknown, but which is due probably to a very chronic infection from an ultra-microscopic virus, which some workers recently claim to have isolated, or possibly to a neoplastic invasion of the lymphatic glands and the lymphoid tissues of the spleen and other organs. The lymphatic glands become enlarged and both they and the lymphadenomatous deposits, which are seen in the Peyer's patches of the bowel and in the spleen (hardbake spleen), have the same microscopic structure, which is characteristic of the disease. The lymphoid cells in the glands are diminished in number, while the endothelial cells are markedly increased, and many giant cells will be found in the gland which are of a peculiar type, in that they are not very large, they have regular outlines, and are multinucleated, their nuclei being scattered throughout the cell body (lymphadenoma cells). The distinction between cortex and medulla is lost, while the fibrous stroma is sometimes abundant, in which case the glands are hard and slow-growing (the so-called stony form) ; in other cases this is more or less absent, the glands then being soft and more rapid in growth, while the disease is altogether more virulent. Localised white tumours of this nature appear in the spleen and Peyer's patches, and occasionally in the kidneys, liver and skin. Very rare cases have been described in which the bone marrow has become filled with a similar deposit. At times the vertebral column is infiltrated with lymphadenomatous deposits and a paraplegia has been produced sufficient to require a laminectomy. The disease is much commoner in young persons or adolescents, and in males rather than in females. Any group of glands may be the first to be affected, but it is most commonly seen in the cervical region first. In some cases one group of glands will remain the only group affected for a long time, but in other cases the glands all over the body become rapidly involved. Abdominal and mediastinal glands are just as liable to be involved as the external ones, and in some instances they are the only glands invaded. When diseased they give rise to many of the most severe symptoms, such as great stridor and respiratory embarrassment. A group of glands in the neck or groin due to this disease is very characteristic. The swellings are soft and elastic, the individual glands being very large and remaining discrete and movable. They appear to exhibit little tendency to become fused together or adherent to the surrounding structures, while they never soften, break down or suppurate. The skin does not become adherent, while the masses of glands themselves are often compared to bunches of grapes. Another characteristic feature is the size of the masses to which they give rise, for they form large projecting tumours often running up and down the whole length of the neck on one or both sides, and when this is so there may be lymphatic œdema of the skin over them. Sooner or later other groups of glands undergo similar changes, the axilla, the groin and the internal glands becoming involved, and all preserving the same characteristics of softness, mobility and discreteness. When the mediastinal glands are considerably involved (and this may be the first symptom) there will be marked signs of pressure both on the superior vena cava, leading to venous engorgement and cyanosis, and upon the air passages; involvement of the abdominal glands will lead to ascites. Some cases are very chronic, the disease remaining confined to one group of glands for many years, and only spreading slowly to others; but in other instances it is far more acute, spreads rapidly over the body and

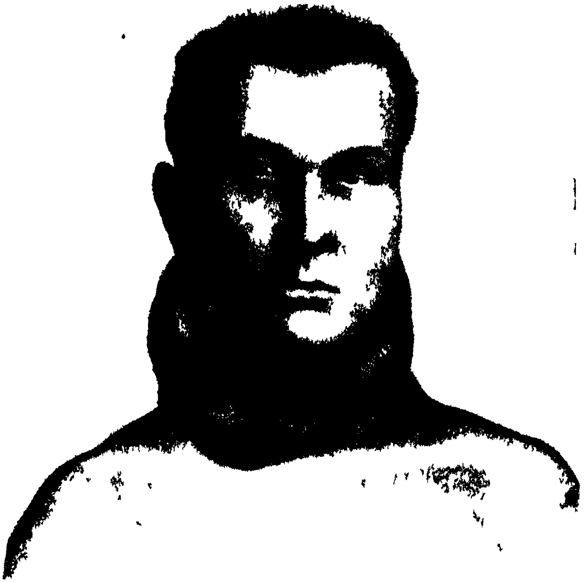


FIG. 179. Hodgkin's disease with diffuse masses of glands in the neck.

causes death within two years. Sooner or later the spleen and liver will become palpable, while the only blood change detectable—and this is always present—is a marked degree of secondary anæmia with a slight lymphocytosis. In the more acute forms there will be marked wave-like attacks of pyrexia, which come on at regular intervals of a month or so, the temperature rising to 102° or 103° and remaining up for a week or ten days and then settling down completely till the next attack occurs (Pel-Ebstein phenomenon). During these febrile stages the glands sometimes swell and become painful. After a time the patient develops cachexia and dies either of increasing weakness or from intrathoracic pressure effects. The prognosis is very bad.

The early diagnosis may be difficult, though the feel of the glands is usually characteristic (see p. 324). In many cases it will be wise to remove a gland and examine it microscopically.

Treatment. The treatment of the condition is largely medical and consists in large doses of arsenic, either by the mouth or by injection, for a considerable time, while salvarsan is sometimes beneficial. There is no doubt that X-rays and radium have at times been markedly beneficial, though even then the condition frequently returns later on. Removal of the glands, except for purposes of diagnosis, seldom does any good, as the disease is too widespread for all the glands to be capable of removal, and even where it appears to be confined to one group, it always appears sooner or later elsewhere. These glands are remarkably easy to remove surgically, as they are non-adherent, but the temptation to do so should be resisted.

The use of a specially prepared chicken serum has been recommended, but we have seen no good come of it.

Lymphæmia. This is essentially a disease of the blood and blood-forming organs, and is of purely medical interest, except that the glandular enlargements to which it gives rise may closely resemble those of Hodgkin's disease. All the lymph glands are usually enlarged and have similar characteristics to those of Hodgkin's disease, but the symptoms are far more severe, and marked and characteristic changes in the blood count are present. The treatment is essentially non-surgical, and consists in the administration of benzol, arsenic and of X-rays. Blood transfusion has also been attempted with little success. On no account should the spleen be removed for this condition.

It is in this condition that the rare tumour a *chloroma* is sometimes seen (see p. 216).

CHAPTER XII

INJURIES AND DISEASES OF THE NERVES

Surgical Anatomy and Physiology. The nerves leave the spinal cord *via* the anterior and the posterior spinal nerve roots, the former conveying motor nerve fibres and the latter sensory nerve fibres. After a very short course these primary roots unite together to form the main spinal nerve root, two of these main spinal nerve roots corresponding to every segment of the spinal cord and passing out between every pair of vertebræ. On leaving the spinal column in most cases these spinal nerve roots unite with their neighbours, split up and unite again, forming complicated plexiform arrangements, as seen in the brachial and lumbo-sacral plexuses, while before entering into these plexiform arrangements the nerve roots receive a varying number of rami communicantes connecting them with the Sympathetic System. The nerves which leave these plexiform arrangements for the most part are mixed nerves, containing both motor and sensory fibres, and these constitute the peripheral nerves of the body ; a few of the larger nerves such as the radial, long saphenous and internal cutaneous are purely sensory.

The twelve cranial nerves are of somewhat similar character except that they come off from the brain and not the spinal cord ; moreover, they have far less tendency to be mixed nerves. Some of them are purely motor, some purely sensory, while some convey the fibres of special sensations.

A peripheral nerve is thus made up of bundles of separate nerve fibres which are chiefly medullated, and held together by a loose connective tissue framework, and each nerve fibre in its turn consists of a number of nerve fibrils, each known as an *axis cylinder*, which depends upon its connection with the central nerve cell in which it originates for its nutrition and integrity ; if it is separated from this nerve cell it undergoes degeneration. Blood vessels and lymphatic vessels run in the connective tissue framework of the nerve. In a medullated nerve each axis cylinder is surrounded by a medullary or myelin sheath which probably acts as an insulating medium, and is interrupted at regular intervals by gaps known as the nodes of Ranvier ; this myelin sheath is enclosed in the neurilemma or sheath of Schwann. Non-medullated nerve fibrils possess a neurilemma but no myelin sheath.

The *motor fibres* of the peripheral nerves originate in the large nerve cells of the anterior horns of the spinal cord and terminate in the fibres of voluntary muscles. The involuntary musculature of the internal organs such as the heart, bowel, bladder, etc., is controlled almost entirely by the Sympathetic System and in some cases by certain of the cranial nerves, and not by the ordinary peripheral nerves.

The distribution and mode of action of the *sensory fibres* of the peripheral nerves, which convey the various sensations of the skin, of the position of joints and of the contractions of muscle, is not known for certain, but the fibres are usually regarded as being of three kinds :—

1. Those which carry *deep sensations*, *i.e.*, the sensation of deep pressure on the tissues, the position a joint takes up on movement and the recognition of the active movement of a muscle. These fibres are thought to leave the peripheral nerves with the branches which go off to the muscles and thence to pass to the muscles, tendons and joints. Thus, provided tendons are not cut, these sensations will remain even when cutaneous nerve trunks are divided. This sensation of pressure is best tested by heavy pressure with a blunt object, while joint sense is examined by placing the joints in various positions while the patient keeps his eyes shut, and asking him to describe in what positions the joints are.

2. Those fibres which convey the highly specialised sensations of the skin, which will appreciate the lightest touches and accurately localise their position, which can detect small differences of temperature and can distinguish as separate such things as the two points of a compass not very far apart. These sensations are described as *epicritic sensations*. They are of exceedingly great importance in the functions of a limb, especially the hand, and when a nerve is damaged they regenerate last of

all and possibly never do so completely. Epicritic sensation of touch is best tested by light stroking with cotton wool, while the sensations of temperature are examined with test tubes of cool and warm water. The patient must keep his eyes shut throughout these tests.

3. Certain fibres which convey the sensations of painful stimuli, *i.e.*, pain in the skin, and marked differences of temperature. These are less specialised sensations and have little accurate localisation; they constitute *protopathic sensibility*. After an injury these fibres regenerate more quickly and more completely than those mentioned above. Protopathic sensations of pain are best tested by pricking with a pin, and of temperature by hot and cold test tubes, the patient again keeping his eyes shut. The pin must be sharp or deep pressure sense will be stimulated.

It must be remembered also that sensory nerves influence the nutrition of the tissues to which they are distributed, and that when a nerve is damaged, especially when it is only incompletely damaged, trophic changes may occur in the tissues supplied by it. Although each nerve has a definite area of skin which it supplies with sensation, neighbouring nerves overlap each other to a very great extent, so that the portion of skin exclusively supplied by any particular nerve is much less than the total area that nerve innervates; this overlap is also more marked in the case of the protopathic sensations than the epicritic fibres.

It has been found by Stöffel and others that in the main peripheral nerve trunks the sensory fibres and the bundles of fibres supplying each individual group of muscles are not arranged in a haphazard fashion throughout the nerve, but that the fibres running to a particular muscle group have usually a more or less constant position in the trunk of the nerve, which can be identified, so that surgical procedures can be undertaken sometimes on individual bundles of fibres in peripheral nerves. This localisation in the cross section of a main peripheral nerve of the situation of fibres supplying individual muscle groups is sufficiently accurately known in some cases to permit of a section of the necessary fibres in spastic conditions of certain muscle groups.

In examining a case where a lesion of a particular nerve is suspected, the whole course of the nerve must be searched carefully for any sign of a scar, wound, or source of pressure. The position of the limb as a whole and the presence of any deformity should be searched for carefully and each individual muscle supplied by the nerve examined, its power and movement tested, and its electrical reactions investigated (see p. 330). All the different forms of sensation in the skin area supplied by the nerve in question must then be carefully tested. It must be remembered that in certain situations a wound may damage more than one nerve and sometimes will involve in addition tendons, vessels and other important structures.

INJURIES OF NERVES

Injuries of nerves are by no means uncommon. They are sometimes the only tissue injured, being affected subcutaneously, but in most cases the injury of a nerve occurs as a complicating factor in some other condition such as a fracture, dislocation or wound, especially a gunshot wound. Nerves may be torn or cut across, they may be bruised or crushed, stretched, torn away from their connection with the spine or pressed upon by involvement in scar tissue or callus or by the pressure of aneurysms or tumours. In some cases the injury appears to be of the nature of a concussion to the nerve, while in other cases the only visible change is a hæmorrhage into the sheath of the nerve. It is distinctly rare to find a nerve involved in callus.

There is evidence that certain nerves are more susceptible to slight injuries than others. Thus the recurrent laryngeal nerve is put out of action temporarily by minor degrees of stretching or handling which would not affect most other nerves at all.

All injuries of nerves may be divided into the two important classes of complete divisions and incomplete divisions, but it must be remembered that a complete division of the nerve does not necessarily mean that the nerve is anatomically completely divided, as in some cases a complete physiological interruption will be found where very few visible changes are to be discovered in the structure of the nerve with the naked eye.

Contusion of Nerves. A contusion or stretching of a nerve trunk is a common and minor form of injury which in most cases gives rise to a small extravasation of blood into the nerve sheath. The symptoms are usually a certain amount of tingling or burning in the area of distribution of the nerve which passes off in an hour or two, while in more severe cases there may be a minor degree of loss of power and of sensation. These more severe cases will be associated with the degeneration of a certain number of nerve fibres (see p. 329), but the function is nearly always completely restored in time. In gouty, syphilitic or rheumatic patients such an injury may be followed by a chronic localised peripheral neuritis leading to partial loss of function of the nerve concerned, and this is sometimes seen in normal individuals as the result of repeated minor injuries to a nerve, especially in the case of the ulnar nerve (see p. 365). No treatment is usually required for a contused nerve.

Concussion of a Nerve. This is a rare condition which has occasionally been seen in connection with gunshot wounds where a bullet or metal fragment, usually with high velocity, has passed through the tissues close to a nerve without actually touching or damaging it. No visible lesion can be seen in the nerve trunk, but it appears temporarily to lose its function more or less completely. Anæsthesia and muscle paralyses will be present to varying degrees, but the muscles do not waste nor do they lose their excitability to the faradic current (see p. 330). Within a few days the nerve begins to recover its function and recovery usually becomes complete within a few weeks unless complicated by the supervention of sepsis in the wound. No degeneration of the nerve takes place, while the only treatment required is support of the paralysed muscle, massage and electricity together with a certain amount of suggestion.

Complete Division of a Nerve. This is a common injury, and is most usually due to accidental wounds produced by fragments of glass from broken bottles or window panes, and by any form of cut, incised wound or gunshot wound. In addition to this, complete **rupture of nerves** without an external wound is seen in connection with fractures, where the violence producing the fracture may damage the nerve, or the nerve may be crushed and torn by the sharp bony fragments ; it also occurs occasionally in dislocations, or as a result of the manipulations required to reduce them. Similar injuries are sometimes seen in the brachial plexus in cases where severe strain is put upon the arms, especially in infants during severe labours. In cases where the nerve is cut across in a wound, the two ends of the nerve will separate often to a considerable degree, while in gunshot wounds large portions of the nerve may actually be torn away and missing. In subcutaneous ruptures, on the other hand, the nerve ends do not as a rule separate, as it is only the nerve fibres which give way, while the sheath remains intact. All these injuries are most commonly seen either round the wrist or in the upper arm and axilla. They are followed the moment after infliction by sharp shooting pain, sometimes resembling an electric shock, though this pain is not always experienced, while immediate loss of function of the nerve concerned, as shown by paralysis and anæsthesia, will follow. The importance of examining every case of injury, cut, wound, fracture or dislocation for the presence of nerve lesions cannot be over-estimated.

The *pathological changes* which follow immediately upon the complete division of a nerve are as follows :—

The two ends of the nerve retract to varying degrees, the space between them filling with blood, which finally becomes converted first into granulation tissue and later into fibrous scar tissue, which will involve and also surround the two ends of the nerve and become intermixed with the nerve fibres therein. The cut ends of the nerve therefore become converted into round, hard, bulbous masses, which are a mixture of fibrous scar tissue and axis cylinders sprouting from the nerve end (in the case of the upper end), being known as **traumatic or terminal neuromata.** Such a terminal neuroma is much more marked on the central than on the peripheral end of the nerve; these become especially big on the ends of nerves which are severed during an amputation, as here there will be an attempt at regeneration of the nerve (see p. 332), which cannot lead, however, to anything, for the limb has been removed. These bulbous swellings or neuromata become especially marked and large when there has been suppuration in the wound or when the nerves have been exposed to the air in the bottom of the wound. Sometimes the two ends of a cut nerve will become connected to one another by means of one of these neuromata. Such a traumatic or terminal neuroma often gives rise to severe neuralgia and may be exceedingly painful and tender.

In **amputation stumps** these terminal neuromata are especially common, and they are very marked in stumps where there has been much sepsis; they are liable to give trouble, for if the nerve has not been cut sufficiently short, they become involved in the scar and give rise to severe pain and such phenomena as paræsthesia or " phantom limbs." When this occurs the neuroma and the portion of the nerve above it will have to be freed and resected, and in some cases the nerve will have to be resected higher up. Intractable cases will be met with in which even this is not sufficient to cause the pain to cease, and then a reamputation at a higher level may be necessary, or even an operation upon the corresponding posterior nerve roots within the spinal canal.

It can be seen thus that when performing amputations it is of great importance to isolate all large nerves, draw them down, crush them, and cut them off some inches higher up ; a catgut ligature may be tied round them in an attempt to prevent their regenerating or alcohol may be injected into the sheath.

Degeneration of a Nerve. Apart from the local changes in a nerve at the site of injury, directly its continuity is interrupted the fibres of the peripheral portion are cut off from their trophic centres in the nerve cells from which they spring and the process of Wallerian degeneration commences within two, three or four days of the injury. There is very little degeneration in the central end of the nerve and it only spreads up to the nearest node of Ranvier, but the whole of the peripheral portion right down to its ultimate and final distribution rapidly undergoes the characteristic changes. These changes consist in the myelin of the nerve segmenting and breaking up into irregular fatlike drops, these drops being finally absorbed by leucocytes and disappearing within a few weeks, while at the same time the axis cylinders swell up and disintegrate, finally disappearing. The cells of the neurilemma proliferate and fibrose, so that when the process is complete (which usually takes one or two months) the peripheral portion of the nerve becomes converted into what is practically a strand of fibrous tissue without any power of conducting either artificial electric stimuli or the nervous impulses for which it is adapted. This process of degeneration occurs inevitably in every nerve which is divided, whatever treatment is applied, and even if immediate suture of the nerve ends is performed.

Clinical Features. The clinical features which are associated with the complete division of a nerve trunk naturally will depend upon the nature and function of the nerve concerned, but in a mixed nerve (which the majority of peripheral nerves are) they will be as follows :—

(*a*) There will be immediate *paralysis of the muscles supplied* by the nerve, which completely lose their voluntary power. They waste rapidly, and in a few days may be reduced to half their proper bulk. In about four days they cease to react to the faradic current at all, this change depending upon the degeneration of the nerve fibres supplying the muscle. A galvanic current, however, continues to excite them for a long time, though after many months their excitability to this type of current will slowly diminish, and it will be found quite early that a stronger galvanic current than usual will be required. It may also be found that the muscle contracts more easily if the anode and not the cathode is applied to the muscle, and also when the current is closed than when it is opened, this loss of excitability to the faradic current and alteration in the way in which the muscle reacts to the galvanic current being known as the **reaction of degeneration,** and becoming fully established in about fourteen days. It will be remembered that a muscle with its normal nerve supply contracts when stimulated both by the faradic and galvanic currents, but more easily with the former and when the electrode is applied over the proper motor points of the muscle. Moreover, when the galvanic current is used the greatest contraction is obtained when the cathode is applied to the muscle and when the current circuit is closed.

This normal state of reaction may be expressed by the formula $KCC > KOC > ACC > AOC$, and also $F > G$. In the reaction of degeneration, however, which occurs soon after the nerve supply is cut off, the formula may become changed to $ACC > AOC > KCC > KOC$, while $F = 0$; though this change is not universal it is common. In addition to this, the response of the muscle is of a much more sluggish type. After some months no electric excitability at all may remain; this means that the muscles are undergoing fatty and fibrous degeneration, but it is not likely to occur for at least four months. As long as the reaction of degeneration is present it is possible that repair of the nerve will give rise to return of muscle function, but when all excitability to both galvanic and faradic currents have disappeared, there is no chance of muscle power returning, as it shows that there is extensive fatty and fibrous degeneration of the muscle tissues. When this has occurred, the fibrosis which will set in will sometimes give rise to shortening and contracture of the muscles concerned, leading to great deformity.

In the case of paralysis of most of the important nerves, the limb or a portion of the limb will often take up an absolutely characteristic position.

While the muscles are paralysed deformity will ensue, if not guarded against, from the over-action of opposing unparalysed muscle groups, and unless proper care is taken the paralysed muscles will become overstretched to such a degree that restoration of function may be impossible even should the nerve recover; this event must be carefully guarded against by proper splintage.

(*b*) *Sensory Changes.* There will be immediate total loss of sensation in some part of the area supplied by the injured nerve, though this will not necessarily correspond to the whole anatomical area supplied by that nerve owing to the overlap of collateral nerves. Thus deep sensation, which is conveyed along the muscles and tendons, will be very little, if at all, affected by injury to one nerve only. There will be an area of loss of epicritic sensation which corresponds roughly to the known anatomical area of cutaneous supply of the nerve concerned, except that it will be rendered rather smaller than this area by the overlap of neighbouring nerves on all sides. In the outer portion of this area of epicritic loss, protopathic sensation will remain and give rise, on minor degrees of stimulation of the skin, to unpleasant tingling sensations. At the central parts of the cutaneous area affected protopathic and epicritic sensations will both be lost. The area of protopathic supply of any individual nerve is rather indefinite, as protopathic supply is distributed more according to nerve root areas than to peripheral nerve areas, so that the overlap of the protopathic areas of different nerves is very marked. It results that the area of loss of protopathic sensation is always less than the area of loss of epicritic sensation, when a peripheral nerve is injured. When, however, a posterior spinal nerve root is severed, the reverse holds good, and the protopathic area of loss is greater than the epicritic. The higher up in a peripheral nerve that the lesion is, the more nearly do the areas of protopathic and epicritic loss correspond. These areas also vary greatly in different nerves ; thus if the external popliteal nerve is divided, the areas of protopathic and epicritic loss very nearly correspond, as this nerve consists almost entirely of the fifth lumbar root. In those areas where protopathic sensation is lost the skin is liable to be damaged by hot water, cigarette ends, etc., while if pricked with a pin it bleeds more freely than it should.

(*c*) *Vasomotor changes* in the parts supplied by the nerve are always present. In most cases the area concerned at first undergoes a rise of temperature, while it may become red and congested as the result of vasomotor paralysis after a few days, however, this temperature falls, the part concerned becoming pale and cold, with a feeble circulation and vitality. Chilblains and blisters are produced, ulceration and sloughing are common, while wounds heal badly, and in cold weather the parts become bluish and may even undergo gangrene. The secretion of sweat may cease, and the skin over the anæsthetic area either become dry and scaly or red, thin and shiny, while in a child the

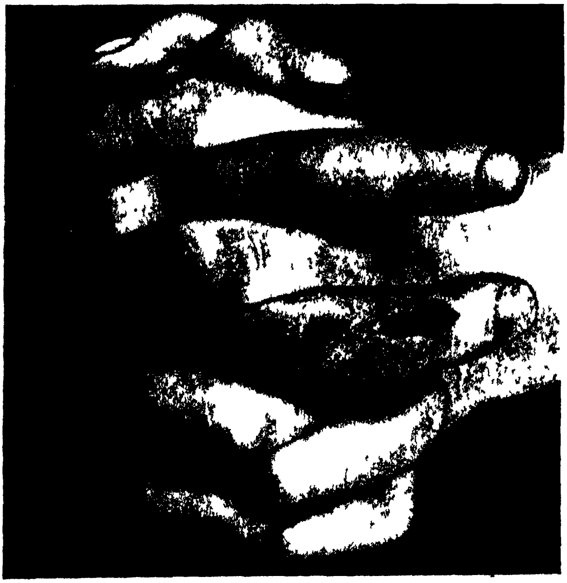


FIG. 180. Median nerve lesion showing trophic ulcers and inability to flex fingers.

development and growth of the part is interfered with, bony atrophy may occur and contraction and ankylosis of the smaller joints are frequently seen. Occasionally the hyperæmia due to the vasomotor paralysis persists and gives rise to a persistent œdema analogous to an angioneurotic œdema.

(*d*) The changes in the skin mentioned above are due partly to vasomotor effects, but also largely to a direct *trophic influence* of the sensory nerves upon the skin. In addition to the above changes, the subcutaneous fat disappears, the nails become brittle and grooved, sometimes thickened, the fingers club-shaped, or sometimes tapering, the hair harsh, brittle, and dry, while as the result of minor injuries, sores and ulcers, which refuse to heal, often will form. Perforating ulcers in the feet occur, and in severe cases the fingers and toes may actually slowly ulcerate away, as is seen in the case of anæsthetic leprosy. The thickening of joint capsules, contraction of ligaments and ankylosis described above are also due to trophic influence, while it is said that in some instances the bones become abnormally brittle.

A few cases have been described which appear to suggest that changes in the central nervous system, giving rise to spasms or paralyses, or sometimes even to fits, may occur as the result of peripheral nerve injuries. This has also occurred in connection with incomplete injuries (see p. 338, Causalgia), but it is doubtful whether these phenomena are not largely functional.

Regeneration of a Nerve. A divided nerve is capable of repair and recovery, but only in a peculiar way, which occurs in no other tissue except possibly tendons ; it can recover its function only if the process of regeneration sets in. As far as is known the process of regeneration of a nerve consists entirely in the axis cylinders of new nerve fibres growing out from the central cut end of the nerve, discovering the peripheral end, possibly by a process analogous to chemiotaxis, entering that peripheral end and slowly growing right down the nerve until they reach its terminal distribution. Any changes that may be discovered in the peripheral end of the nerve itself before this occurs are, according to this theory, not playing any active part in the restoration of the function of the nerve, but are merely preparatory to the downgrowth of the axis cylinders from above. These axis cylinders which grow down from the central end are not myelinated at first, but they grow on until they reach the peripheral nerve terminations in muscles, skin, joints, etc., and finally develop a myelin sheath ; meanwhile the cells of the neurilemma multiply and grow out actively in both ends of the nerve in order to supply a sheath and a support for the axis cylinders. It thus will be seen that the process of regeneration, consisting as it does of a downgrowth of axis cylinders from above, will be slow and take many months and that it will take longer to become complete the greater the distance between the injured spot on the nerve and its peripheral distribution, both of which facts are borne out in practice. It will be seen also that the more specialised, active and minute the movements which the nerve controls, the less likely it is that complete and perfect restoration of power will ever occur ; while in mixed nerves, containing both motor and sensory fibres, and in those which supply large numbers of small muscles, regeneration and restoration of function are never likely to be perfect, on account of the risk that axis cylinders growing down from above and intended to supply particular muscles or sensory nerve endings may find their way by mistake into tracks in the peripheral parts of the nerves which will lead them to structures for which they are not intended. This also is well borne out in practice in that it is found that regeneration and restoration of function are far more perfect and complete in the musculo-spiral and external popliteal nerves than in any other nerves in the body, these being practically purely motor nerves and only controlling comparatively coarse movements; whereas in the ulnar and median nerves, controlling as they do the finest and most specialised movements of the fingers and the most delicate sensory functions of the hand, regeneration and restoration of function are, unfortunately, never complete.

It follows therefore that if the wound remains aseptic and the cut ends of the divided nerve remain in contact or are placed in contact and sutured soon after the injury (especially if they are accurately sutured, so that the surfaces of the two ends correspond completely), the downgrowth of the axis cylinders giving rise to the regeneration of the nerve has the best possible chance; whereas if suppuration and infection occur, even if the nerve ends are accurately in contact, the inflammation is likely to destroy young nerve fibrils, while the excessive formation of scar tissue will also hinder their downgrowth and thus regeneration is likely to be less perfect.

On the other hand, if the ends of the nerve are not in contact or are separated by a considérable interval, there is very little chance of the axis cylinders finding their way down from the central end into the peripheral portion, even if healing by first intention occurs. In this case a bulbous neuroma forms on the central end, while the peripheral end becomes completely degenerated and converted into a fibrous cord, which, at its cut end, also may have a small bulbous swelling, and all function is permanently lost.

Clinically, the first sign of regeneration and return of function in a nerve is a return of sensation, first of all of the protopathic type only, the anæsthetic area gradually diminishing in size concentrically. The time taken for this to occur depends entirely upon the distance the axis cylinders have to grow. It has been found by means of Tinel's sign (see below) that these axis cylinders grow down at the rate of approximately a millimetre a day, and thus there can, as a rule, be no hope of return of sensation under a considerable number of weeks, the average period for the first return of sensation being between sixty and one hundred days. Epicritic sensation will follow next, commencing a month or two later, but it will take a very long time and never be complete, while motor power will take much longer still to return. Restoration of motor function does not usually commence for at least six months and may take many years to become complete, if it ever does so. When only protopathic sensation has returned, touching the affected area gives an unpleasant diffuse sensation of tingling, while as sensation returns the area insensitive to pain steadily diminishes, sensations of extremes of temperature next reappear, and finally, the epicritic sensations of light touch, minor degrees of temperature and discrimination of compass points will become possible. Great care must be taken at this stage to prevent the formation of trophic lesions, which are very liable to occur. When the motor power commences to return it is seen first of all in those muscles which are nearest the injury. Before voluntary power returns there probably will be a more brisk response to galvanic stimulation, while faradic excitability is sometimes delayed even after voluntary contraction has set in. Trophic changes in the skin and other structures sometimes appear to get worse while the nerve is regenerating, but they finally disappear before regeneration is complete. Apart from the factors already mentioned as influencing the amount and completeness of the regeneration, the interval between the injury and the time at which the nerve is sutured plays an important part, as the longer the interval the less the restoration of function will be, and the longer it will take. Various nerves also exhibit great differences in the times they take to regenerate; the musculo-spiral and external popliteal nerves usually recover completely within eight to twelve months; the median and ulnar never recover completely and take a very long time to undergo partial recovery.

Tinel's sign for estimating the extent of regeneration depends upon the following facts. Growing axis cylinders which have not got their myelin sheath are sensitive, and when pressed upon, manipulated or tapped give rise to an unpleasant tingling sensation known as formication, which is referred not to the locality pressed upon, but to the peripheral distribution of the nerve to which that particular axis cylinder goes or used to go. Thus by pinching or pressing a regenerating nerve this tingling sensation will be produced, and by pressing upon a nerve and following its course upwards with the pressure until a point is reached where formication is no longer produced by pressure, we can ascertain exactly how far the new axis cylinders have grown and the process of regeneration can thus be traced downwards. Pressing upon the proximal or central end of a nerve which has just been divided gives rise to no formication; this only commences when, after a week or two, regeneration has started and axis cylinders have commenced to grow. When the axis cylinders are completely grown and have received their myelin sheath, tingling on pressure disappears. In addition to showing how far regeneration has proceeded, this sign is sometimes useful in a doubtful case in showing whether the nerve is divided at all, where it is divided, whether its division is complete or incomplete, and whether regeneration is commencing or not. It must be remembered, of course, that this sign is only observable in those nerves which convey sensory fibres, *i.e.*, sensory nerves or mixed nerves; we must not expect it in pure motor nerves.

Treatment of a Completely Divided Nerve. The treatment in a case of division of any main nerve of the extremities consists in operation performed as soon as possible in order accurately to suture the ends of the nerve. This always should be done immediately, when the wound is receiving its first treatment. The only exceptions to this rule are in cases:—

(*a*) Where the nerve is small and of no importance.

(*b*) Where it is doubtful whether the nerve is completely divided or not.

(*c*) Where the presence of severe sepsis in a wound inflicted some days previously or other conditions render immediate operation inadvisable.

Primary Suture. This is the operation of choice, therefore, in the case of a recently divided nerve, and it should be done, if possible, while the wound is receiving its first regular treatment, which will consist in cleaning and suturing. If the nerve is not sutured within an hour or two of the injury, owing to the nerve lesion not being diagnosed, or the necessary apparatus or skill not being available, the nerve suture should be performed as soon after as possible provided the wound is not grossly infected.

For primary suture to be successful, the preservation of asepsis is essential. The wound, if necessary, should be enlarged, the ends of the nerve be found, cut square if lacerated, brought together, and sewn into accurate apposition with each other, without any tension, lateral displacement or twisting. The suture is best performed with the finest possible round-bodied needle, thin catgut being used; several stitches are inserted, of which only one or two pass through the nerve itself, the remainder only passing through its sheath; it is essential that there should be no tension on the nerve, and in the case of a primary suture this is easily achieved. The wound should be treated according to general principles (see p. 41) to render it aseptic, and after suture the nerve should be buried between muscles if possible. No foreign material, such as Cargile membrane, should be wrapped round it, but a layer of fat or fascia may be folded round it with advantage. At the end of the operation the wound is completely closed with sutures, without drainage. It is of great importance when operating upon nerves that they should not be squeezed or pinched by forceps, should not be unduly stretched or pulled upon, and that, when the ends are trimmed or refreshed, this should be done with the knife and not with scissors.

After the operation it is essential to relax the paralysed muscles completely by proper splintage to prevent them becoming stretched, while means must be taken as soon as possible to preserve the nutrition of the joints and paralysed muscles. These consist in massage, movement of all the joints, protection from heat or cold, and electrical treatment, which will take the form of the stimulation of the muscles concerned with the *galvanic* current (the faradic having no effect). It will be necessary, of course, to have the galvanic current switched on and off continually, as the muscle contractions will only occur when the current is switched on and off. Electric baths and the application of sinusoidal currents are specially advantageous. This post-operative treatment will have to be continued for many months until regeneration appears to be complete.

The results of primary suture are usually satisfactory, though they depend largely upon the nerve concerned and the situation of the injury. In the case of a wound the suture should be performed within a few hours if possible, before infection can supervene. Should the case be seen a few days after the injury, when sepsis has already set in, no attempt should be made to suture the nerve until the wound has healed and all sepsis has disappeared for at least a month.

Secondary Suture. Although primary suture is the operation of choice, it is not always possible to perform it; thus sometimes it is difficult to make certain immediately after the injury that the nerve has been completely divided and that the symptoms are not due to a concussion or to a partial lesion, while suture of a nerve can never be performed in a wound which is suppurating, or for some weeks after such sepsis has ceased, as organisms may lie latent in the scar tissue for a long time. In these cases the nerve will have to be explored and sutured some weeks or months after the injury, and the operation is then known as secondary suture. If the symptoms of paralysis, anæsthesia and trophic changes have remained without alteration for months, there should be no delay in performing a secondary nerve suture. Before the operation is performed the electric reaction of the muscles must be carefully tested, for complete absence of response to the galvanic current shows that the muscles are beyond the power of recovery, and in such a case there is no object in suturing the nerve except to get rid of trophic lesions if present; if the galvanic current produces a smart response, or still more if there is some reaction to faradic stimulation, it shows that the nerve is commencing to regenerate, and the operation therefore should be further delayed. The operation will be far more difficult than that of primary suture, for in this case abundant scar tissue will be present, one or both ends of the nerve may be difficult to find, and they will have retracted away from each other, so that great difficulty may be experienced in bringing them together; moreover, neuromata probably will be present on one or both ends. It is best to find the nerve trunk an inch or two above and below the injured site;

the two ends are then dissected free, bulbous neuromata and fibrous tissue removed from the nerve ends by successive sections until what appears to be healthy nerve fibres are visible. These sections should be made with a sharp knife and not with scissors, so as not to crush the nerve; the ends should then be stitched together as already described. Great difficulty may be experienced after the scar tissue has been resected in bringing the ends into contact with one another without tension. If the nerve is set free for some distance above and below, the two ends can be stretched towards each other to a small extent; while by flexing and extending certain joints a great deal of difference in the tension of the nerve will be effected. In most cases flexion of the joints releases the nerves, but in the case of the elbow and the ulna nerve, extension of the joint relaxes the nerve. Here it often will be found useful to transplant the ulnar nerve from behind the condyle of the humerus and bring it to the front of the bone. Every effort should be made to bridge a gap in the nerve in this way, for the results so obtained are far better than those obtained by grafting, introduction of tubes, etc.

If by the above methods the two ends of the nerve cannot be brought together, one or other of the following means may be employed, but the results in all cases will be found to be poor. (*a*) Flaps of the nerves may be turned up or down in order to bridge the gap, but this is unscientific. (*b*) The two ends of the cut nerve may be implanted into the side of a neighbouring healthy nerve in the hope that axis cylinders will grow down from one to the other within the sheath of the healthy nerve. This is scientific, but poor in results. (*c*) Nerve grafting is sometimes employed, whereby a portion of a nerve of no import, such as the radial nerve, is removed and sewn into the gap in the injured nerve; or nerves have been obtained from animals or amputated limbs for this purpose. The results of this proceeding are poor, though Ballance has recently shown that such a nerve graft takes better if it is allowed to degenerate for twelve days before it is inserted. (*d*) The bones of the limb have sometimes been shortened to allow the nerve ends to be brought together. This increases the chance of nerve regeneration considerably, but may give rise to much interference with the action of the muscles and tendons. (*e*) The introduction of sections of veins, tubes and foreign materials, such as long guiding catgut or silk sutures, in the hope that the growing axis cylinders may be guided down them from the upper to the lower end of the nerve, need only be mentioned to be condemned as utterly useless.

The results of a secondary nerve suture depend largely upon the delay between the operation and the injury, the longer the delay the poorer the results. In any case, a longer time will be required for the regeneration of the nerve, and the amount of recovery is not likely to be as complete as in the case of a primary suture. If during the interval there has been any attempt at regeneration, as may be the case, resection of the nerve and suture, of course, will lead to the disappearance of any commencing recovery that may have occurred. After a secondary suture the post-operative treatment of splintage, massage, electricity, etc., described on p. 335, must be carried out with the same care as after a primary suture. This treatment may last a very long time and require great patience and perseverance on the part of the patient. Re-educational exercises and suggestion to aid the patient's will power will therefore also be helpful. When during the operation a joint has had to be fixed in a position of extreme flexion to permit of the nerve ends being brought together, this fixed position must be maintained for three weeks after the operation. The limb may then be gradually straightened out by leaving the splintage off and applying graduated passive extension. It will take three or four weeks to straighten the joint completely. In a certain number of cases it is impossible to bring the ends of the nerve into contact or there may be such complete degeneration that there is no prospect of recovery ; or recovery may fail to occur, even when suture has been satisfactorily performed. When this is so certain plastic operations may be necessary in the form of tendon transplantations and grafts, etc., which will aid the function of the patient's limb greatly (see under " Individual Nerves ").

Incomplete Division of a Nerve. This condition is comparatively common in wounds produced by sharp instruments (*i.e.*, punctured wounds), bullets or small shell fragments, while a physiologically incomplete division of a nerve, in which there is no visible anatomical lesion in the structure of the nerve, is also seen at times (see p. 328). If the nerve is partially cut or notched, those fibres which are cut retract and a gap involving one part of the nerve appears, which ultimately becomes filled by fibrous scar tissue and axis cylinders, adherent to the scar in the surrounding tissues. This mass of scar tissue sometimes forms a definite swelling on the nerve and is then known as a *lateral neuroma* or a *central neuroma*, according to its situation.

Clinical Features. These depend on the nature of the nerve injured, and upon the site and extent of the lesion. Certain muscles supplied by the nerve will be paralysed completely and the reaction of degeneration will set in, whereas other muscles supplied by the same nerve appear to be unaffected. There is thus a dissociated paralysis, while the fact that the fibres supplying particular muscle groups are constantly localised in the same portion of the nerve trunk will often give an indication as to which portion of the nerve is injured.

The sensory changes also will be irregular and the anæsthesia will be much less marked than in a complete lesion, as also will be the vasomotor changes , epicritic sensation is chiefly affected. A partial lesion of a nerve, however, sometimes will give rise to irritative phenomena, especially if much scar tissue is present, if a foreign body is embedded in the nerve, or if a neuroma is present upon part of the nerve. These take the form, firstly, of trophic changes as

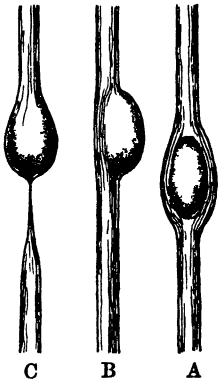


FIG. 181. Three types of neuromata : A. A central neuroma. B. A lateral neuroma. C. A terminal neuroma.

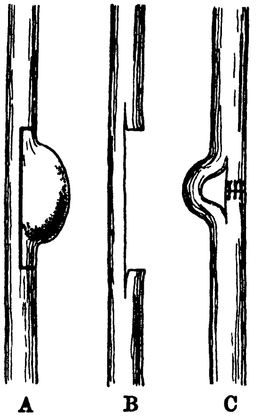


FIG. 182. The method of removing a lateral neuroma : A. Incisions made. B. Neuroma excised. C. Nerve repaired.

described on p. 331, only even more severe, the skin becoming thin, glazed' shiny and of a blue or red colour, the fat disappearing, the hair falling out, the nails being rough and brittle; the skin may be covered by scabs and scales as the result of excessive secretion of sebum and sweat. In addition to this there is frequently an intense burning pain of the most severe kind and referred to the area of skin supplied by the nerve injured. This does not commence for some weeks after the injury, but may persist for years. It is known as **Causalgia**, and gives rise to the most intense suffering, the burning sensation coming on in paroxysms, often started by a touch on the skin area affected, by warmth and movement, or even by external stimuli such as noises or lights. It prevents sleep and sometimes may lead to mental changes, while it is usually associated with a peculiar glossy condition of the skin affected. Its cause is unknown, but it is possibly due to a spreading fibrosis or neuritis of the nerve trunk. It is most commonly seen in partial lesions of the median or internal popliteal nerves.

A partial reaction of degeneration is sometimes seen in incomplete nerve injuries, in which the muscle contracts sluggishly when stimulated by the galvanic current, but also retains a certain amount of irritability to the faradic current.

Treatment. In the case of a partial lesion of a nerve the treatment does not consist in immediate operation, but the condition should be watched carefully for a time to see if any signs of improvement or regeneration are present. If after three months there is no improvement or if regeneration and restoration of function cease before recovery is perfect, the nerve should then be explored. The greatest care must be taken not to damage any portion of it which is intact. A lateral or central neuroma should be excised carefully and those fibres which are cut, refreshed and sutured. In many cases of partial lesion of a nerve the cause is a compression of the nerve trunk rather than an actual injury, the signs, symptoms and treatment of which will be described below.

The *treatment of causalgia* is difficult. The application of cold wet dressings to the skin area affected and the administration of morphia are the only things which will relieve the pain when it is present, but they do not prevent its onset. Exploration of the nerve, setting it free from scar tissue, and the removal of neuromata will sometimes effect a cure, while in other cases the nerve may be injected with 80 per cent. alcohol. This will relieve the pain but destroys the function of the nerve. In other intractable cases where this does no good, resection of the nerve higher up may be necessary, but this, of course, will destroy its function completely ; nor does this always relieve the pain. Even section of the posterior nerve roots or division of the antero-lateral columns of the spinal cord has sometimes failed to give relief, and when this is so it must be assumed that the pain is of mental origin rather than physical, and that it is the result of the fixed impression that he is in severe pain which has so long been present in the patient's mind. After many years the pain tends to die out on its own.

Compression of Nerves. Compression of a nerve may be regarded as a subcutaneous injury and it may be due to several causes ; thus in some cases a nerve will become involved and pressed upon by contracting scar tissue or by scarring and very rarely callus from a neighbouring fracture, the signs and symptoms due to these conditions not appearing for some weeks or months after the injury was inflicted. There may have been a primary partial or complete lesion of the nerve, recovery from which is prevented by the subsequent development of pressure upon the nerve. The symptoms of such a condition are nearly always those of a partial nerve injury rather than those of a complete injury and they usually tend to get worse for a time. Occasionally terminal cutaneous nerve twigs will be involved in a scar and give rise to severe pain on pressure or movement, while in other cases pressure upon the nerve will be due to the development of tumours or aneurysms. In all these instances the signs and symptoms come on gradually and consist partly of irritative phenomena, as shown by neuralgic pain and muscle spasms, and later of a partial muscular paralysis combined with a certain amount of anæsthesia, both usually incomplete. The area of loss of protopathic sensation is usually greater than that of epicritic loss.

Treatment. If after a few weeks the condition shows no signs of recovery, the nerve must be explored and, if possible, the cause of the pressure removed. This will consist in the removal of scar tissue, callus, etc., as the case may be. Attempts must be made to prevent the future formation of scar tissue round the nerve by embedding it in healthy muscle or fat; the insertion of foreign material round the nerve, such as Cargile membrane, etc., is worse than useless, as it simply increases the scar tissue. In the case of a small twig adhering to a scar and causing pain, the nerve should be freed and the scar excised, and in some cases the application of radium or X-rays will relieve this condition.

Pressure Palsies. Another form of nerve injury due to compression is the result of traumatism in the form of direct pressure upon the nerve, of either a momentary or prolonged nature. Thus this is seen as the result of crutch pressure in the axilla, where the musculo-spiral nerve is usually involved; of pressure from splints, which is seen especially round the neck of the fibula, where it involves the external popliteal nerve; and the so-called "drunkard's paralysis," where several nerves in the upper arm become paralysed as the result of the patient going to sleep with the arm resting over the back of a chair or pressing upon some other hard object. In other cases the pressure of a tourniquet, a dislocated bone, or faulty position of the arm while the patient is lying upon the operating table under an anæsthetic, will give rise to similar symptoms, and in some of these cases it is possible that the injury is due, not so much to pressure upon the nerve as to stretching, either of the nerve itself or of the muscles which are found to be paralysed.

In other instances a nerve will be crushed suddenly by a blow or a fragment of bone in a fracture, the pressure then lasting only a very short time. In all these injuries the symptoms are usually those of a partial and not a complete division of the nerve. Thus anæsthesia is not complete, only certain of the muscles supplied lose their power, and though there may be considerable wasting, the normal electrical reactions are usually found to be present in the muscles. Trophic changes are not usually seen.

Treatment. This depends upon the nature of the lesion. In most of these cases recovery takes place spontaneously within a few weeks unless the reaction of degeneration is present. When this latter condition is found, spontaneous recovery is unlikely and exploration of the nerve will be required. Such an exploration may lead to the removal of a displaced bone or mass of callus pressing upon the nerve, excision of fibrous scar tissue around it, or in some cases to actual transplantation of the nerve itself. Whether operation is necessary or not, careful splintage to prevent the occurrence of deformities and of overstretching of the paralysed muscles, and massage and electrical treatment to keep up the nutrition of the muscles are of the greatest importance.

Dislocation of Nerves. Nerves which run in a groove in a bone are occasionally found to be dislocated out of their groove in a way rather similar to that in which tendons are dislocated. The condition is almost unknown except in the case of the ulnar nerve, and is described on p. 368.

DISEASES OF NERVES

Neuritis or inflammation of nerves occurs in two forms, the acute and the chronic, the latter being known as multiple peripheral neuritis, chronic neuritis or perineuritis.

Multiple Peripheral Neuritis. This is by far the commoner condition, and is usually regarded as a medical rather than a surgical disease. Pathologically it is found that there is an increase in the connective tissue both within and around the nerve, which gives rise to compression and degeneration of the conducting fibres. It sometimes results from injuries, especially repeated minor injuries, in which case it is confined to one nerve, but more often it is the result of constitutional conditions, such as alcoholism, chronic lead or arsenic poisoning and toxic conditions associated with diabetes, diphtheria, influenza, beri-beri, leprosy, syphilis, rheumatism, tuberculosis, renal disease, gout, malaria or typhoid. In these conditions many different nerves are affected simultaneously, although it is found in practice that the alcoholic form chiefly affects the legs and gives rise to tenderness of the muscles, dropping of the feet and toes, perforating ulcers of the foot and inability to walk, whereas the diphtheric form affects the soft palate and muscles of deglutition, and that due to lead poisoning affects the optic nerves and the muscles of the arms and gives rise to wrist drop. Neuralgic pain is often present at the commencement, while the nerves affected can often be felt to be thickened, hard and tender. The paralysis comes on comparatively rapidly, varies considerably from day to day and is of the lower motor neurone type. Anæsthesia and trophic changes are usually slight.

Treatment. The treatment of this condition is chiefly medical and is directed at the cause, but it is important to take measures to prevent deformity resulting from the paralyses and to preserve the nutrition of the nerves and muscles by massage, baths, douches, and electrical treatment; thus splintage will be required, and in some cases where deformities have already occurred, operative treatment will be necessary. If recovery is much delayed, benefit may be obtained by puncturing the nerves affected with a needle.

Acute Neuritis is a much less common condition, and is usually due either to injury, gout, rheumatism or the presence of an infected and septic wound leading down to or involving the nerve itself. All the changes characteristic of acute inflammation are found in the nerve and especially in its sheath, which is swollen, red, tender and engorged. Later it passes on into a condition of chronic neuritis with overgrowth of fibrous tissue and degeneration of axis cylinders. The symptoms are first of all hyperæsthesia and intense neuralgic pain in the course of the nerve concerned and referred down all its branches, while the main nerve trunk may be felt to be swollen and tender. The muscles it supplies may twitch and become wasted and weak, but it is not likely that there will be any definite anæsthesia, paralysis, or trophic lesions. In the later stages the condition will be unrecognisable from peripheral neuritis, above described, except that only one nerve will be affected.

Treatment. The limb must be put at rest, constitutional causes such as gout, rheumatism and sepsis must receive appropriate treatment, while over the course of the nerve itself applications such as belladonna, or menthol, and dry heat, hot air baths, leeching, dry cupping, or even blistering may be tried. In more severe and persistent cases the nerve may be stretched or punctured with a needle or saline injected into its sheath. Operative exploration of the nerve should be undertaken only :—

(*a*) If it is a purely sensory nerve ;

(*b*) If there is any possibility of its being involved in scar tissue, callus or adhesions ; and

(*c*) If the pain is intolerable.

Neuralgia. Neuralgia is a common condition and is the term applied to a pain usually of a paroxysmal or intermittent character and lancinating, darting or stabbing, which follows the course and distribution of a particular nerve. It is really a symptom and not a disease, but as the term should be employed only in those cases where no cause for the pain can be discovered (*i.e.*, it should not be used in cases of referred pain due to pressure upon a nerve by tumours, aneurysms, etc.), it may not unreasonably be described as though it were a clinical entity. The pain of neuralgia is paroxysmal ; it usually commences suddenly, increases for a certain time, reaches a maximum, and then gradually or suddenly passes off. Recurrences of the pain are frequent and may be brought on by various forms of stimuli, such as touching the portion of skin affected, or by cold, heat, noises, lights, etc. The nerve trunks involved are often tender, though pressure on them sometimes will relieve the pain, and the skin supplied by them exhibits specially hyperæsthetic and tender points, and may be flushed or œdematous ; the hair sometimes drops out. Muscles supplied by the nerve or neighbouring nerves sometimes pass into spasm during the attack ; affected glands secrete excessively, while herpes will appear on the skin areas concerned. The causes of a neuralgia of this kind are obscure. General toxic conditions play an important part, especially syphilis, gout, pyorrhœa, rheumatism and malaria, whereas in other cases the condition is reflex and referred from some diseased organ elsewhere, such as the teeth, the bowel or the ovary. Hysteria, anæmia, and mental anxiety and worry undoubtedly predispose to the condition. Although any nerve, sensory or mixed, may be subject to the disease, it is usually only seen in the fifth cranial nerve, the dental nerves, the sciatic, the brachial plexus, the intercostal nerves, and in such organs as the breast, testicle, prostate and rectum.

Before diagnosing a case as one of neuralgia, every possible cause of neuritis must be excluded and careful search made for any sources of reflex irritation, the most likely causes being :—

(*a*) In the head—teeth, disease of the nose or nasal sinuses, middle ear disease, glaucoma, iritis, astigmatism or myopia, and growths in the mouth and tongue.

(*b*) In the trunk—spinal caries, aneurysms, tabes, or herpes.

(*c*) In the limbs—diseases of joints or bones, cervical ribs, heart conditions, and deformities of the feet and legs.

Treatment. The treatment of this condition consists essentially in removing the cause when it can be discovered. In addition to this or when no cause can be discovered, the general health should be improved in every possible way. Spa treatment, electrotherapy and ionisation often will be useful, while such drugs as aspirin, valerian, asafœtida, pyramidon, quinine, iron, arsenic, gelsemium, phenacetin, caffeine, menthol, etc., are valuable. In many cases surgical treatment will effect a cure. Thus in sensory nerves, the nerve may be destroyed by the injection into it of 80 per cent. alcohol or of saline solution. Division of nerves, resection of the nerve, avulsion of the nerve or even the division of spinal or cranial nerve roots may be necessary (see p. 347). In the case of mixed nerves anything that destroys the nerve isundesirable, because of the paralysis it causes. In this case the nerve should be stretched, needled, or injected with saline (see p. 371).

Brachial Neuralgia. In this condition the pain, which has the characteristics of neuralgia, is located in the distribution of one or more of the branches of the brachial plexus. It is often accompanied by tingling and disturbances of sensation. The condition must not be diagnosed until all possible forms of irritation of the nerve trunks or their terminal twigs have been excluded, and in most cases the pain will be found to be due to an aneurysm, tumour, cervical rib, angina, osteoarthritic shoulder joint, arteriosclerosis, etc., while there is always the possibility that it is due to some disease in the arm itself. Other cases have been described in which pain of this kind is due to pressure on the brachial plexus exerted by a *normal first rib,* and is relieved when that rib is resected. The treatment of this condition consists in the removal, if possible, of any cause that may be found ; if this fails the nerve trunks may be injected with saline or the trunks may be stretched. If the condition is very severe, it is sometimes justifiable to resect certain of the primary posterior spinal nerve roots (as indicated by the locality of the pain) within the vertebral canal.

Sciatica and **trigeminal neuralgia** are described in connection with the individual nerves on pp. 345, 370.

Tumours of Nerves. All tumours arising in nerves are given the name of **neuromata,** whether they arise in the true nervous tissues or in the fibrous supporting structures. If composed only of nerve cells they are called **true neuromata,** if ganglion cells are present, **ganglionic neuromata,** these tumours being rare, more common in the abdominal sympathetic system than elsewhere, and sometimes malignant. Tumours arising in the sheath of the nerve and consisting chiefly of fibrous tissue are called **false neuromata,** and these may be localised or diffuse, also simple or malignant. The diffuse form of generalised neurofibromatosis, which tends to run in families and is accompanied by pigmentation of the skin, mental changes and sometimes malignant changes in some of the tumours, is known as **Von Recklinghausen's Disease.**

A **plexiform neuroma** is a neurofibromatosis of several contiguous nerves, while occasionally the condition is so marked and gives rise to so much enlargement of a whole limb that it is given the name of **Elephantiasis Neuromatosa.** For a full description of all these conditions, see p. 196.

THE SURGERY OF INDIVIDUAL NERVES

The Cranial Nerves. Paralyses or irritations of the various cranial nerves form some of the most important symptoms indicative of disease of the brain itself, while such symptoms are of great value in the localisation of injuries and cerebral tumours. In many of these cases the lesion which affects the function of the nerve is really a lesion of the nerve centre and not of its trunk. When the lesion affects the centre for a cranial nerve, any paralysis produced is of the upper motor neurone type and is usually on the opposite side to the lesion. We are here, however, only concerned with lesions of the trunks of the cranial nerves, in which case the paralysis is of the lower motor neurone type, and, with the possible exception of the optic nerve, is on the same side of the body as the lesion itself.

A lesion of a cranial nerve trunk may be due to direct injury, such as tearing or contusion, especially as the result of fractures of the base of the skull, to hæmorrhage into the nerve sheath, or to pressure upon the nerve by callus, scar tissue, inflammatory exudates, tumours, gummata, aneurysms, or the chronic forms of meningitis. The disturbances of function produced by these lesions, therefore, may come on suddenly or gradually, may be permanent or may pass off slowly, and the way and rate at which such disturbances of function set in will often be indicative of the nature of the lesion in the nerve trunk. Thus if the nerve is directly damaged by an injury, its function disappears at once ; if due to hæmorrhage, the loss of function comes on in a few minutes or hours, if to inflammation, in a few hours or days, if to scar tissue or callus, not for some weeks or months ; if to tumour formation or chronic inflammation, it will take months or years.

The fifth, seventh, eleventh and twelfth nerves are those which are most likely to concern the surgeon.

(I.) **The Olfactory Nerve** or some of the branches are sometimes torn by fractures running across the anterior fossa of the skull and involving the cribriform plate, while contusions of the anterior lobes of the brain, tumours, and meningitis in this situation may also involve it. The only symptom is a complete loss of smell; if the nerve is torn this will be permanent, but if the condition is due to pressure on or hæmorrhage into its sheath the loss of smell may be only temporary. It must be remembered that complete loss of smell interferes greatly with the power of taste and is a very distressing symptom. The aura of epileptic fits sometimes takes the form of sensations of smell. The function of the olfactory nerve should be tested with such aromatic odours as cloves or peppermint, and not with irritative gases, such as ammonia, as these latter will stimulate the sensory nerve endings of the fifth nerve.

(II.) **The Optic Nerve.** An injury of the optic nerve leads to complete blindness in the eye on the side concerned, which will be temporary or permanent according to the nature of the damage to the nerve. The nerve may be torn by fractures of the front of the base of the skull or by penetrating wounds in this neighbourhood or in the orbit, while pressure is frequently exerted upon it by hæmorrhage into its sheath, inflammatory exudates, tumours, gummata, aneurysms or scar tissue. Orbital cellulitis will give rise to pressure on this nerve, and in the case of this condition or of hæmorrhage into the sheath, vision ultimately may be partially restored if the pressure has not been too severe or too prolonged. Prolonged and severe pressure on the nerve will lead to optic atrophy and a permanent loss of vision.

Optic neuritis, or, as it is more commonly called, *Papillœdema* (Vol. II., Chapter VI.), which is an intense œdema of the ending of the nerve in the eyeball, is a condition commonly associated with increased intracranial tension. It is frequently double, and is usually the result of a cerebral tumour, abscess, or inflammation, while it is usually followed by optic atrophy and blindness.

It must not be forgotten that lesions of one optic tract or of one of the occipital centres for sight give rise to hemianopia, *i.e.*, loss of sight in one half of the field of vision of each eye, and in this case Wernicke's pupil reaction will show the level of the lesion. Pressure on the optic chiasma, as by a pituitary tumour, causes bitemporal hemianopia (see Vol. II., Chapter I.).

There are innumerable toxic and medical conditions, both local and general, which cause interference with the function of the optic nerve.

(III.) **The Oculo-Motor Nerve.** This nerve may be lacerated by fractures of the base of the skull near the sphenoidal fissure, or it may be compressed by hæmorrhage ; while tumours and aneurysms, either in the orbit or within the skull, and especially gummata arising near the floor of the third ventricle, will also give rise to pressure upon it, and in this case sometimes it will happen that the nerves on both sides are involved. Its centre may be affected by degenerative changes in the brain.

This nerve is a purely motor nerve, and the symptoms caused by its complete paralysis are ptosis or dropping of the upper eyelid from paralysis of the levator palpebræ and external squint from paralysis of all the recti muscles except the rectus externus, while the eye is also rotated a little downwards, so that there will be diplopia. The pupil is dilated as the muscles of the iris are paralysed, and there will be loss of accommodation and of reaction to light owing to palsy of the ciliary muscle. It must be remembered that in some cases where the nerve is pressed upon by blood clot a fixed dilation of the pupil is the only sign that appears (Vol. II., Chapter I.). The extensive paralysis of the ocular muscles which occurs when this nerve is involved usually gives rise to a slight amount of exophthalmos. Partial paralysis of this nerve is more common than complete loss of function. It must be remembered that lesions of the third nerve will frequently be accompanied by lesions of the other nerves close to it, namely, the fourth, fifth and sixth nerves. If all the muscles of the eye are paralysed the condition is known as **ophthalmoplegia externa**, and this is nearly always the result of syphilitic disease affecting the floor of the third ventricle.

(IV.) **The Pathetic Nerve.** Lesions of this nerve are rare ; they are due to the same causes as in the case of the third nerve. When it is paralysed there is diplopia when the patient looks downwards, and there is defective movement of the eyeball in a downward and inward direction. The patient finds difficulty in going downstairs.

The *treatment* of lesions of the foregoing nerves consists entirely in the removal of the cause of the lesion if possible. There is no treatment which can be directed at the nerves themselves.

(V.) **The Trigeminal Nerve.** This nerve or one of its branches may be pressed upon by effusions, tumours, aneurysms or gummata, while it is sometimes torn by fractures of the upper jaw or of the base of the skull, the symptoms then being complete anæsthesia of the skin area supplied by the injured branch. If the ophthalmic division is injured the conjunctiva and cornea become insensitive, when ulceration of the cornea is liable to follow as the result of dust and foreign bodies falling on its surface, which, in its insensitive state, tolerates them so that they set up irritation and inflammation. When the petrous portion of the temporal bone is fractured the *great and small superficial petrosal nerves* may be ruptured, with the result that the patient complains of earache and difficulty in swallowing, while the soft palate is paralysed.

The motor portion of the nerve may be involved in these injuries and cause paralysis of the muscles of mastication ; this leads to very little inconvenience, as the muscles on the opposite side suffice ; the jaw, however, will be deflected slightly towards the paralysed side by the opposite external pterygoid muscle. Spasm of the muscles of mastication (trismus) is a common condition.

Sensory changes in the nerve also will be caused by any of the above conditions ; they take the form of severe pain and anæsthesia over the area supplied by the nerve.

Tumours of the Gasserian ganglion are occasionally seen. These are usually gliomata or fibrosarcomata, and may cause symptoms similar to those of tic douloureux (see below).

Trigeminal Neuralgia (Tic Douloureux). This is a common condition usually seen in elderly women, though no age is immune, more frequently on the right side, and consists of an intense epileptiform neuralgia of the branches of the fifth nerve. The name is applied only to those cases of neuralgia where there is no pressure or irritation of the nerve itself, and no sources of peripheral irritation, such as carious teeth, disease of the tongue, eyes, jaws, or nose, nasal sinuses or middle ear, or scars on the scalp or face, and the possibility of irritative foci in all these situations must be carefully excluded before the above diagnosis is made. Little is known of the cause of the condition, though it is probably due either to an ascending neuritis from a peripheral infection (usually dental) or to degenerative changes in the Gasserian ganglion. In some cases tumours have been found involving this ganglion or the root of the nerve behind it (but these cases are associated with anæsthesia of the skin), while in other cases no changes whatever can be detected. Trigeminal neuralgia has been known for hundreds of years, and even in the fourteenth century the tomb of Bishop Button, in Wells Cathedral, was vaunted as that of the patron saint for facial neuralgia. Many famous and infamous people have suffered from it, including in the first class Lord Lawrence, of the Indian Mutiny, and in the second Judge Jeffries. Violent emotion sometimes has the effect of starting the pain and at other times of stopping it, though usually there is no definite exciting cause. Weight is lent to the probability that the disease is in some way the result of septic teeth and septic neuritis by the fact that it is only in the fifth nerve and the glosso-pharyngeal nerve that such intense neuralgia is seen, these nerves both supplying the mouth. The pain never crosses the middle line or goes to the back of the head. The condition is sometimes definitely associated with disseminated sclerosis, though even then there is no facial anæsthesia, while at times clonic facial spasm is seen.

This is one of the most painful and terrible diseases that exist. It is invariably unilateral and commences without apparent cause with pain which occurs in paroxysms, and is usually at first localised to the infraorbital or inferior dental branches. At first these paroxysms occur at long intervals and are only moderately severe, lasting perhaps for a few seconds, but as the disease progresses they become very much more frequent, the pain becomes agonising and spreads to the other divisions of the nerve, the paroxysms ultimately becoming more or less continuous and utterly prostrating the patient, while they are usually excited by some trifling cause, such as eating or speaking, touching the face, cold draughts of air, and sudden noises or lights. The pain is described as burning or like red-hot needles running into the face. Even in very severe cases the first or ophthalmic division of the nerve appears to be less affected than the other divisions. Between the attacks the patient is free from pain, but in such constant terror of its returning that she hardly dares to speak or move, and wears a constant look of anxiety on her face. The paroxysms are often accompanied by twitching of the facial muscles and of the muscles of the neck, while there may be salivation and unilateral sweating and hyperæmia of the head, the hair becoming grey or falling out, marked lachrymation and excessive secretion of saliva or nasal mucus ; there is, however, no anæsthesia of the skin. After a time the skin of the affected portion of the face becomes glazed or red, or covered with dried sweat and dirt as the patient dares not touch it or wash it, while certain points of excessive tenderness develop, pressure on which is perfectly intolerable and precipitates the paroxysms. The mucous membrane of the cheek and mouth is also red and tender. In advanced cases the patient can take no part in life, hardly dares to eat, cannot sleep, and ultimately becomes wasted, suicidal or a drug maniac. The condition must be distinguished from hysterical neuralgia by the fact that in the latter disease the pain varies in situation, is often bilateral, and is not paroxysmal; while those cases where the pain is due to a local irritation of some part of the nerve can be distinguished by the continuous character of the pain, and its relief when the local irritation is removed. This latter form of neuralgia is sometimes called Neuralgia Minor, true tic douloureux being named Neuralgia Major. Other conditions which must be distinguished are headache from general causes, lightning pains of tabes which occasionally occur in the fifth nerve, and herpes zoster ophthalmicus.

Treatment. As a preliminary to treatment every source must be searched for a possible reflex irritation, and if such a one is found it must be removed, although it is not wise to remove teeth which appear to be perfectly healthy. In addition to this, the general health must be improved in every possible way and a trial given to all the ordinary medical methods used in the treatment of neuralgia. Change of residence and departure to a warmer climate hardly ever helps. It will be found probably that the only drug capable of controlling the pain is morphia, but the tendency to form a habit is great. In the true disease, however, it is most unlikely that these methods will prove effective, and when that is so, operative treatment will have to be undertaken; when this has been decided upon the first variety of treatment to be adopted is that of alcohol injection.

Alcohol Injection (Schlosser's Method). Since no peripheral focus of irritation is present, and as far as we know the cause of the disease lies in the Gasserian ganglion itself, injections of alcohol into any of the three divisions of the trigeminal nerve are not likely to be effective and should no longer be practised. The first treatment, therefore, to be tried for this condition is an injection of alcohol into the cave of Meckel and around the Gasserian ganglion itself in the hope of completely destroying the nerve cells and fibres there present. The operation may be performed under a general anæsthetic, the patient being only just anæsthetised and retaining his conjunctival reflex, or under morphia and scopolamine or by means of avertin; 80 per cent. alcohol and a long needle are used. The patient's mouth is opened, the needle is inserted through the skin of the face in the preauricular region half an inch below the zygoma and passed inwards through the lowest part of the sigmoid notch of the mandible. The needle is then pushed inwards, upwards and slightly backwards until it strikes bone, this being the under surface of the greater wing of the sphenoid, and the tip of the needle is then made to pass directly inwards until its point is felt to enter a hole in the bone, this foramen being the foramen ovale. The needle is then pushed inwards for not quite another half-inch, when the tip of the needle should lie in the cave of Meckel and be in contact with the ganglion. Three cubic centimetres of alcohol are then injected. If the needle enters the foramen ovale correctly and the patient is lightly anæsthetised he will be seen to flinch or even cry out as the result of the pain caused when the needle pierces the third division of the nerve. If this injection has been made satisfactorily a complete anæsthesia will develop rapidly in the whole cutaneous distribution of the fifth nerve, though the ophthalmic division will be the least affected, and anæsthesia of the cornea and conjunctiva may or may not result. Sometimes there is no anæsthesia although the pain disappears. A successful injection of this kind is usually followed by complete relief from pain for a period of from six months to three years. Should the pain then return further injections may be given, though they tend to become less and less effective when repeated.

Hartel's Method. Another method of performing this injection is through the front of the cheek, but this is less easy, as there are fewer bony landmarks to act as guides. The needle is inserted into the cheek either 1–2 cm. lateral to the corner of the mouth or 2–3 cm. above it, and is guided between the buccinator and the mandible by a finger in the mouth. It reaches the intratemporal crest of the sphenoid and then the foramen ovale.

Should this method of injection fail or be impossible, or recurrence occur rapidly after it, further operative treatment will have to be undertaken; here, again, it will be found that operations devised to attack the various divisions of the fifth nerve will not be successful or give rise to relief of any duration and, therefore, such operations as section, stretching, or resection and avulsion of any of the main divisions of this nerve should no longer be performed. The operation which holds out the best prospect of a permanent cure consists in a resection of the fifth root behind the Gasserian ganglion, and between it and the pons. This has replaced the older operation, which consisted in the removal of the greater part of the Gasserian ganglion itself (*Gasserectomy*). A small portion of its upper and inner part was left in situ as the first division of the nerve is not frequently involved in the neuralgia, and also the upper part of the Gasserian ganglion is adherent to the cavernous sinus. By leaving this portion of the ganglion intact, the motor portion of the fifth nerve passing to the muscles of mastication remained uninjured. Should it for one reason or another be thought wise to attempt to resect the second or third divisions of the nerve, this had far better be done from within the skull by an operation very similar to that for removing the Gasserian ganglion. The foramen through which the root concerned leaves the skull then may be plugged permanently with a silver, gold, or platinum screw, or, less expensively, with a gutta-percha plug.

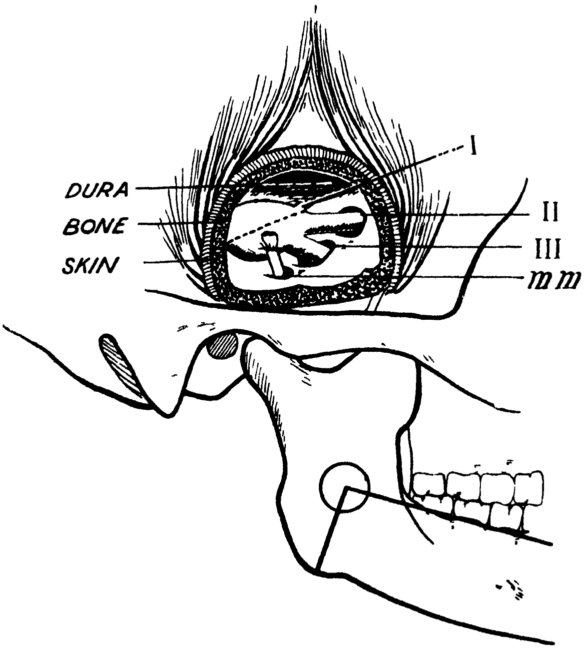


FIG. 183. Method of approaching the Gasserian ganglion in the temporal region. The ganglion and the three main divisions of the nerve are seen while the line of section is indicated. On the lower jaw the site selected for trephining the bone to expose the inferior dental nerve is shown; mm is the middle meningeal artery tied and cut.

The main root of the fifth nerve or the Gasserian ganglion is best approached through the temporal region of the skull, the older pterygoid approach not giving sufficient room, and the operation now performed is a modification of the Hartley-Krause operation. A small scalp flap is turned down in the temporal region and the skull trephined just above the zygoma, an opening about the size of half a crown being required. The dura is not opened, but is gently stripped up from the middle fossa by forcing plugs of gauze soaked in saline between it and the bone. The middle meningeal artery will be encountered and tied just above the foramen spinosum or the foramen may be plugged. Two Cushing's silver clips may be applied to it and the vessel divided between them. It is essential that the operation field should be absolutely free from blood, and other hæmorrhage must be stopped by gentle pressure, the dura mater and temporo-sphenoidal lobe are held up by a retractor and the stripping of the dura continued until the cavernous sinus is almost reached. A suction apparatus will render the field of view much more clear. When the second and third divisions of the nerve are seen running out through their foramina, they are followed back by pushing up the dura. The spot where the dura splits into two layers to form the cave of Meckel is marked by a white line and the dura must be pushed up until this is identified. The cave of Meckel is then opened into and the ganglion, or the main fifth root, can be exposed. It is important not to open the main dura of the middle fossa or the wound will be flooded with cerebro-spinal fluid and the operation. difficult enough, will become even more troublesome. Care must be taken also not to wound the cavernous sinus. After excision of the ganglion the cornea probably will be insensitive and must be protected from irritation for the first two or three months by means of a watch glass fixed round the orbit; in some cases it is wise to stitch the lids together for the first week. Ulceration does not, however, occur after resection of the fifth root. The patients should be warned beforehand that their face is going to be completely anæsthetic on one side. The results of the operation are uniformly good as regards relief from pain, though, of course, it will be followed by anæsthesia of the face, forehead, part of the scalp, anterior part of the auditory meatus, nose, and mucous membrane of the cheeks and gums. The operation is difficult, but in skilled hands the mortality is very small.

Supraorbital Neuralgia. This nerve is seldom involved in tic douloureux, but is subject to an intractable and distressing form of neuralgia independently of the other branches of the fifth nerve, the pain frequently recurring at the same time each day, and being in many cases cured by small doses of quinine and morphia. If this medical treatment fails, excision of the nerve should be performed. The nerve is exposed by an excision along the eyebrow over the supraorbital notch, and when it has been exposed the periosteum is incised and pushed downwards, so that the nerve can be traced back into the orbit for some distance and a considerable portion of it excised.

Inferior Dental Neuralgia is a not uncommon condition and is the result of persistent dental troubles previously, which cause the nerve to swell and become compressed in its bony canal, so that the pain persists after all teeth have been removed. It is then best to cut the inferior dental nerve by trephining the outer wall of the mandible and exposing the nerve in its canal.

Lingual Neuralgia and severe pain in the tongue are sometimes encountered in malignant disease in this organ (Vol. II., Chapter V.). The lingual nerve may then be cut by a tenotome by means of an incision through the mucous membrane of the gum, half an inch below the last lower molar tooth. The lingual nerve also may be cut through the same opening in the lower jaw described above.

(VI.) **The Abducens nerve** may be injured in fractures of the base or penetrating wounds; it is also pressed upon by tumours, aneurysms, gummata, or meningitis. Though it has the longest intracranial course of any of the cranial nerves it is comparatively seldom involved in any lesion. When paralysed it gives rise to paralysis of the rectus externus, leading to an internal squint and diplopia.

(VII.) The Facial Nerve. This is a purely motor nerve except for the fact that certain taste fibres run with the facial nerve for part of its intracranial course. Lesions of this nerve may be due to many different causes and usually lead to paralysis of the face muscles. Such a paralysis may be due to supranuclear, nuclear, or infranuclear lesions, the nucleus of the nerve being in the floor of the fourth ventricle.

(*a*) *Intracranial Lesions.* If the lesion of the nerve is situated anywhere between the facial motor cortex and the facial nucleus in the pons, the paralysis will be of the upper motor neurone type, without reaction of degeneration, will occur on the side of the face opposite to that of the lesion, and will affect the lower half of the face more than the upper half, the muscles of the forehead and eyelids usually escaping, and the voluntary movements more than the involuntary motions of expression. If actually due to a cortical lesion, such as a hæmorrhage or tumour, only a portion of the face will be involved ; if subcortical, in the corona radiata or the corpus striatum, it will probably be accompanied by hemiplegia also. If, however, the pontine facial nucleus is involved or any portion of the facial nerve below this nucleus, either inside the skull, in the petrous bone or outside the skull, the paralysis will be of the lower motor neurone type with reaction of degeneration and on the same side as the lesion, while the muscles will rapidly atrophy, both the top and lower portions of the face will be equally affected, and the emotional movements will suffer equally with the voluntary ones. These intracranial lesions of the facial nerve may be due to hæmorrhage, traumatic or apoplectic, abscesses, tumours, thrombosis, embolism or degenerative lesions. They are naturally usually accompanied by other signs and symptoms.

(*b*) *Peripheral Causes.* Here we are dealing with a lower motor neurone paralysis and the lesions may lie either within the bones of the skull or outside the skull ; thus within the petrous bone a fracture of the base of the skull will sometimes involve the facial nerve either by lacerating it, by hæmorrhage into its sheath, or more commonly later on as the result of the formation of scar tissue or callus. All these injuries are, however, rare.

Chronic middle ear suppuration frequently will give rise to a lesion of the nerve in this part of its course, for inflammatory effusions or granulation tissue may press upon it while it lies in the aqueductus Fallopii ; in children the infection actually may destroy the nerve, while in other instances the surgeon may damage it accidentally in performing a mastoid operation; tuberculous or malignant disease of the middle ear frequently will involve it. In this intrapetrosal part of its course any lesion which affects the facial nerve is liable also to involve either the auditory nerve and give rise to deafness, or the petrosal nerves, in which case there also will be paralysis of the palate, the uvula being pulled over towards the sound side : if above the chorda tympani branch, there also will be loss of taste on the same side of the tongue. Outside its intra-osseous course a series of extracranial lesions of the nerve may occur. It may be injured here by operations on the mastoid or upon the parotid gland or on glands in the neck, while it will be involved by such diseases as malignant disease of the parotid, parotitis, or blows or pressure on the nerve. A common variety of lesion in this situation is known as **Bell's Palsy**, and is probably a neuritis of a rheumatic nature and due to exposure to cold ; it affects that part of the nerve which curls round the condyle of the jaw to enter the parotid gland. In these extracranial lesions the whole of one side of the face is paralysed equally, both voluntary and emotional movements ; the paralysis is of a lower motor neurone type and the palate and uvula are unaffected. It is often found that an incision high up in the neck under the jaw, as for removal of glands, or ligature of the lingual artery damages the small cervical branch of the nerve which goes to supply the platysma and orbicularis oris at the corner of the mouth; this may cause slight drooping of the corner of the mouth for some months.

Clinical Features. In complete facial paralysis the affected side of the face is smooth, expressionless and motionless, all the natural folds and creases disappearing, the cheek being flattened and smooth and the muscles flaccid, while the corner of the mouth on the paralysed side may droop slightly. The palpebral fissure is wider than usual. The eye cannot be closed, and on attempting to do so the eyeball can be seen to roll upwards and outwards, while the conjunctival reflex is lost. The lower lid droops away from the eyeball and this, together possibly with the loss of the suction action of the lachrymal sac from the paralysis of the tendo oculi and tensor tarsi, causes the tears to run down the face instead of down the lachrymal duct (epiphora). The patient cannot wink, so that the conjunctiva becomes dry and even may ulcerate. When the patient moves his face, as in smiling, only the muscles on the sound side act, so that the face is drawn over to that side, while the forehead cannot be wrinkled and the ala nasi falls in. The buccinator is paralysed, so that he cannot whistle, suck, blow out his cheeks, or prevent the food collecting between the cheek and the teeth, the aid of a finger during and after a meal is necessary to prevent this. The paralysis of the orbicularis oris renders him unable to show his teeth, while it may interfere with his speech and prevent the clear pronunciation of the labials. If that part of the nerve associated with the chorda tympani is involved there will be a loss of taste. If the condition is bilateral it may be far less noticeable than when it is unilateral. In some cases where the tongue is protruded it appears to be displaced to one side, but this is not really the case. Occasionally upper motor neurone lesions of the facial nerve will be followed by contractions of the muscles which cause the creases to appear deeper than normal.

Treatment. In all cases a hook suspended around the ear should be worn in the corner of the mouth to support the paralysed muscles. The cause of the condition must be removed if possible. Those cases which are rheumatic or due to exposure to cold (Bell's Palsy) will recover in the course of a few weeks under the influence of potassium iodide, strychnine, and massage and electrical treatment, while if the nerve has been accidentally divided, immediate suture should be performed if possible. If the reaction of degeneration is present and the paralysis has lasted for more than four months, spontaneous recovery is highly unlikely, and operation should then be performed. In many cases suture of the nerve is impossible, especially when it has been divided within its bony course, or if the condition is due to some lesion, which cannot be removed; and then the operation of **nerve anastomosis** will have to be performed. The peripheral end of the facial nerve is first exposed; the hypoglossal nerve is then laid bare and either cut, or a flap of it turned up and its central end grafted on to the peripheral end of the facial nerve. In other cases the central end of the spinal accessory nerve has been used for this purpose instead of the hypoglossal.

The results of this operation have been encouraging, and after some months the facial movements slowly return. At first at any rate, they will be accompanied by, in fact be initiated by, movements of the tongue or of the shoulder, according to which of the two above nerves have been used. After a time, however, the patient learns to dissociate the movements. The hypoglossal nerve is the better nerve to select for this operation, as its cortical centre is nearer that of the facial nerve and the associated movements of tongue and face are easier to dissociate and less troublesome to the patient than association of shoulder and face movements. Either the hypoglossal or the spinal accessory nerves are far easier to find than the atrophied peripheral end of the facial nerve.

Grafts of the degenerated radial nerve have been employed with success, especially where the facial nerve has been damaged, as it frequently is, in the Fallopian aqueduct.

If operation fails or is impossible, the asymmetry of the face often may be improved by grafting a portion of the masseter, which is supplied by the fifth nerve, into the corner of the mouth on the paralysed side; or the corner of the mouth may be slung up to the zygoma by the implantation of a strip of fascia or a long silk suture.

Facial Tic (Histrionic Spasm). This is a continual clonic, painless contraction of the facial muscles, seen usually in elderly women. Sometimes all the muscles are involved, more commonly only some of them, especially the orbicularis oculi, in which case the eyelids are continually undergoing twitchings and jerky movements. In some cases, especially the partial ones, this condition is due to an irritative lesion in the cortex or pons; in other cases it is a reflex phenomenon due to irritation of portions of the trigeminal nerve, especially as a result of disease of the teeth or of the nasal cavities. The condition causes great annoyance, both to the patient and her friends. Very severe cases are sometimes seen where all the facial muscles and also the platysma are involved; these are usually due to some intrapetrous irritation of the facial nerve trunk.

The *treatment* consists in removing any source of peripheral irritation, in administering anti-spasmodics or nerve tonics, and in improving the general health, while counter-irritants over the nerve trunk should be tried. These remedies frequently fail, and in this case the facial nerve should be injected with alcohol, stretched or even, in severe cases, divided, just below the point where it leaves the stylo-mastoid foramen. The results of stretching the facial nerve have not been good. Facial-hypoglossal anastomosis has sometimes been performed for this condition as well as the last with a fair amount of success.

(VIII.) The Auditory Nerve. This may be damaged, together with the facial nerve, in fractures of the base of the skull running through the internal auditory meatus, either on one or both sides, while it also will be involved by tumours of the cerebello-pontine angle, many of which are fibromata actually growing from the sheath of this nerve and capable of removal (Vol. II., Chapter I.). Complete deafness is the result of injuries to this nerve, but if the lesion is only an effusion of blood into its sheath, there is some prospect of its passing off in time: in this case it may be accompanied by giddiness and noises in the ear (see Vol. II., Chapter VII.).

(IX.) The Glosso-pharyngeal Nerve. This nerve is very rarely involved in any lesion, traumatic or otherwise. Were such an injury to occur it would lead probably to ulceration of the tongue and interference with speech and swallowing.

Glosso-pharyngeal Neuralgia. Rarely paroxysmal pain occurs in the area of distribution of the glosso-pharyngeal nerve, very similar to that of trigeminal neuralgia and having the same characteristics of spasmodic nature and spontaneous origin. The pain is felt chiefly in the back of the tongue, the throat, the pillars of the fauces and the ear. Sensations of tickling and dryness also occur in the throat. The tympanic branch of the nerve, to the middle ear, mastoid and Eustachian tube, is especially liable to be involved. This branch of the nerve may possibly explain the pain so often felt in the ear in late cases of carcinoma far back on the tongue.

Treatment. Medical treatment usually gives little relief after a time, and operation is nearly always required in the end. The nerve may be sectioned either inside the skull in the posterior fossa or avulsed as high up in the neck as possible. In this case the tympanic branch which is in the bone and unapproachable is torn off.

(X.) **The Vagus Nerve.** This is most commonly injured in the neck where it is occasionally divided or tied during operations upon lymphatic glands, goitres or the carotid artery. Such an accident, however, can be regarded only as carelessness. There is considerable difference between the symptoms, according to whether the nerve is completely divided or only irritated, and whether the lesion is above or below the point where its recurrent laryngeal branch leaves it. Below the point where this branch leaves it, complete division of the nerve on one side only may cause little or no symptoms, though there may be some palpitation and pulmonary congestion. If, however, it is irritated by pressure with forceps or by being accidentally ligatured, there will be a temporary inhibition of the heart-beat, coughing and sometimes persistent vomiting. If both nerves are divided the effect is serious, and death will result probably from interference with the heart's action or œdema and congestion of the lungs.

If the lesion of the nerve occurs above the point where its recurrent laryngeal branch comes off, any of the above symptoms may occur, together with other effects due to the involvement of this branch (see below). Successful cases have been reported of suture of the vagus, and if it is divided accidentally during an operation this should be done at once.

If the superior laryngeal branch is injured, or the vagus cut above where this branch leaves it, the larynx will be rendered insensitive, and this often will lead to inspiration pneumonia.

The Recurrent Laryngeal Nerve. This branch of the vagus is of great importance, as it supplies the abductor and adductor muscles of the vocal cords. The nerve is sometimes injured during the operation of thyroidectomy, though in this case it is not usually cut, being more commonly stretched or squeezed; it is also frequently pressed upon by aneurysms and malignant growths of the chest or neck. It also may be injured by stabs or bullet wounds in the neck. This nerve appears to be abnormally sensitive to minor injuries, and especially those fibres which supply the abductor muscles, so that slight degrees of stretching or squeezing which would have no effect on another nerve are sufficient to put these fibres out of action. Lesions of the recurrent laryngeal nerve may be complete or partial, the latter being the most common when the nerve is pressed upon by an aneurysm, malignant growth, etc., and this is more common on the left side. An incomplete lesion of the nerve leads to an abductor paralysis; a complete one to a complete paralysis of the vocal cord, in which case the cord affected takes up what is known as the cadaveric position, the results in either case being interference with phonation and respiration to varying degrees. A bilateral abductor paralysis may be very serious and lead to intense stridor requiring tracheotomy (Vol. II., Chapter IX.). Adductor paralysis is usually confined to hysterical females. If possible any case of division of the recurrent laryngeal nerve should be treated by immediate suture; recovery of function has been recorded after this.

(XI.) The Spinal Accessory Nerve. This nerve is at times divided accidentally in operations upon glands high up in the posterior or anterior triangle while rarely it is damaged where it leaves the skull by fractures of the posterior fossa. In other instances it is irritated during its course by any of the above conditions. It supplies the sternomastoid and trapezius, but it is not the sole supply of these muscles, so that in many cases when it is divided or paralysed very little disablement follows. If the nerve is injured in the anterior triangle both these muscles may be paralysed, while if the lesion is in the posterior triangle only the trapezius will be affected. In other instances or if other nerves are damaged as well, the paralysis of the trapezius causes the shoulder to droop, the arm to hang by the side, and the head to be inclined forward, while the scapula is slightly rotated and further from the spine than on the other side. Wasting of the muscles will follow, and there is difficulty in lifting the arm above the head; the whole arm also feels weak from the imperfect fixation of the scapula. Clonic spasm of the muscles supplied by this nerve occurs in the condition known as spasmodic torticollis (see Vol. II., Chapter X.).

If this nerve is divided it should be sutured at once or, if this is impossible, at a later date. Failing this, its peripheral end may be anastomosed to the central end of one of the other motor cervical nerves. For spasmodic torticollis the nerve should be stretched or even divided. The nerve enters the anterior border of the sterno-mastoid one inch below a point midway between the angle of the jaw and the tip of the mastoid process, emerging from under the lower border of the posterior belly of the digastric. It should be found here and then may be cut or stretched. The operation is not, however, followed by good results as a rule.

(XII.) The Hypoglossal Nerve. This nerve has been cut in operations upon lymph glands or upon the lingual artery and in cut throats. It has been damaged in fractures of the posterior fossa or pressed upon by aneurysms, growths and chronic meningitis. Unilateral paralysis of the tongue is produced and the paralysed half atrophies. When the tongue is protruded the unparalysed muscles push the substance of the organ over towards the paralysed side, while there may be interference with speech and the swallowing of food. After a time the patient learns to overcome these disabilities.

THE SPINAL NERVES

The cervical plexus and its branches are seldom injured, nor do any very serious signs and symptoms follow should this occur.

The Phrenic Nerve. This nerve supplies the diaphragm and is occasionally injured accidentally during operations on the neck or as a result of accidental wounds.

Irritation of the phrenic nerve is one of the causes of hiccough, which is a distressing condition at times, and may be stopped in some cases by sudden sharp stimulation of cutaneous branches of the cervical nerves arising from the same region of the spine as does the phrenic.

Phrenic Avulsion. A section, crushing or avulsion of the phrenic nerve is frequently performed on one side of the neck in cases of unilateral phthisis, bronchiectasis and other conditions in order to reduce the movement and encourage compression of the lung on that side, as that half of the diaphragm rises and ceases to move. It is frequently combined with a thoracoplasty

(Vol. II., Chapter XI.). Under local anæsthesia the nerve is exposed in the neck where it is running down on the scalenus anticus by a transverse incision; gradual traction is made on it and as much as possible of it is drawn out. Often the whole nerve is pulled off the diaphragm and drawn up into the neck.

Double phrenic paralysis causes the abdomen to be sucked in instead of protruded during inspiration.

THE BRACHIAL PLEXUS AND ITS BRANCHES

This plexus consists of the lower four cervical and first dorsal anterior primary nerve roots. These roots are distributed roughly as follows:—

Fifth Cervical — to the deltoid, biceps, brachialis anticus, supra- and infraspinati, rhomboids and the supinator muscles.

Sixth Cervical — to the pronators, serratus magnus, upper part of pectoralis major and the radial extensors of the wrist.

Seventh Cervical—to the triceps, remainder of pectoralis major, the extensors of the fingers and extensor carpi ulnaris.

Eighth Cervical—to the flexors of the wrist and fingers.

First Dorsal—to the small intrinsic muscles of the hand.

It must be remembered that most of the above muscles are supplied by more than one root, but the above represents their main supply.

The sensory skin areas supplied by these roots are shown in the diagrams on pp. 354 and 355.

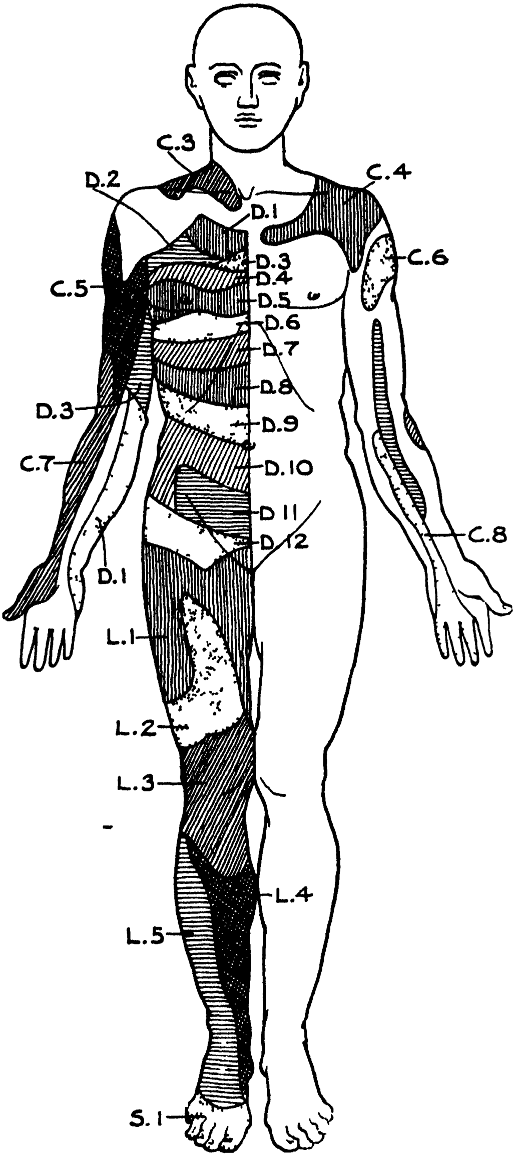


FIG. 184. The sensory distribution of the spinal nerve roots on the anterior aspect.

The Brachial Plexus. It is customary to describe injuries of the brachial plexus under two headings, namely, supraclavicular and infraclavicular injuries, but the most important point in their diagnosis is to discover which roots, trunks or cords are injured and at what level, independently of their relation to the clavicle. Cuts or stabs in the lower part of the posterior triangle of the neck may injure the upper parts of the plexus, while it is common for the nerves to be torn, stretched or bruised as the result of the arm being dragged suddenly upwards (as when the weight of the body is thrown with a jerk on to the arms extended above the head, or in clutching at a support when falling), by stretching of the head upwards or sideways, or by violent depression of the shoulder, so that the head and shoulder are forced in opposite directions. Long-continued hyperextension of the arm or severe flexion of the head under an anæsthetic, dislocations of the shoulder, fractures of the clavicle, attempts to reduce dislocations, the pressure of aneurysms either of the subclavian or axillary vessels, and the presence of new growths or cervical ribs, also will give rise to lesions of different parts of the plexus, while such injuries occur in infants as the result of damage during severe labours. These lesions may consist in tearing the nerve roots away from the spine, complete or partial rupture of nerve trunks or of hæmorrhage into the sheaths. During the process of healing a great excess of fibrous scar tissue is formed, which may interfere greatly with regeneration. Dislocations usually damage the inner cord, while hyperextension of the arm by clutching at a support when falling is most likely to involve the eighth cervical and first dorsal roots. In the cases of anæsthetic paralysis due to hyperextending and externally rotating the arm above the head it is usually the fifth and sixth roots which are damaged. A cervical rib usually damages the eighth cervical and first dorsal nerves, while in the case of a fractured clavicle the injury is more likely to be due to the violence causing the accident than to the fragments of the

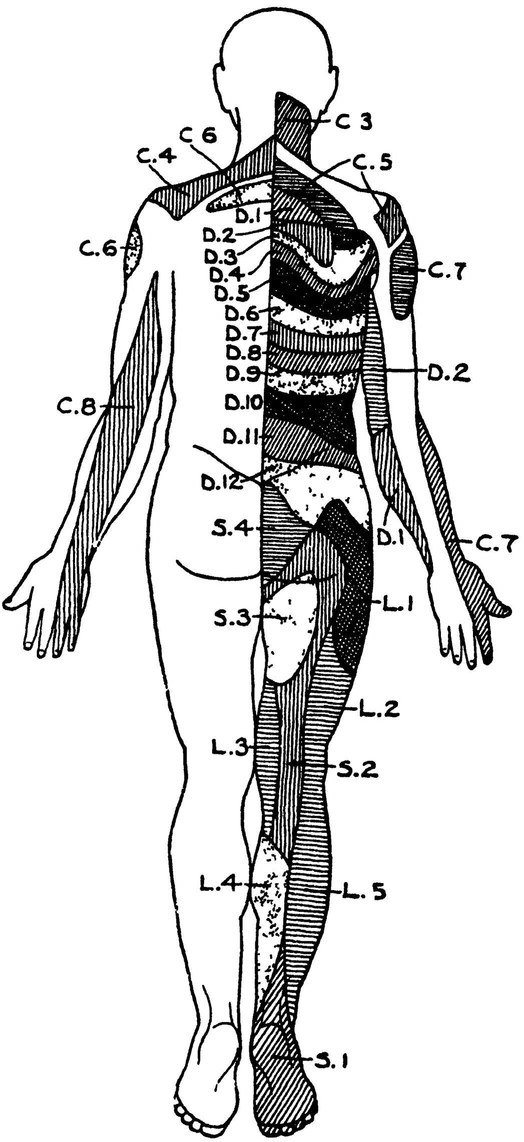


FIG. 185. Sensory distribution of the spinal nerve roots on the posterior aspect.

bone, and any of the nerves may then be involved. It will be seen that the causes of brachial plexus lesions may be roughly divided into Traction and Pressure.

Clinical Features. Clinically, three types of lesions are found, which are regarded as *supraclavicular* injuries, namely :—

(*a*) Those which involve the whole plexus, *i.e.*, the complete lesion.

(*b*) The upper arm type.

(*c*) The lower arm type.

(*a*) If the **whole plexus** is involved all the muscles of the arm, hand and forearm are completely paralysed and flaccid, the pectorals and supra- and infra-spinati may or may not be involved, while the rhomboids and serratus magnus usually escape. There will be anæsthesia over the whole hand, the whole forearm, and over the greater part of the outer surface of the upper arm, while the upper half of the inner side of the upper arm retains its sensation owing to the intercosto-humeral nerve. Deep touch will be lost over the forearm. Inasmuch as the first dorsal nerve is involved, there may be sympathetic paralysis of the eye, which gives rise to a contracted pupil, dilating slowly, a narrow palpebral fissure and enophthalmos (see

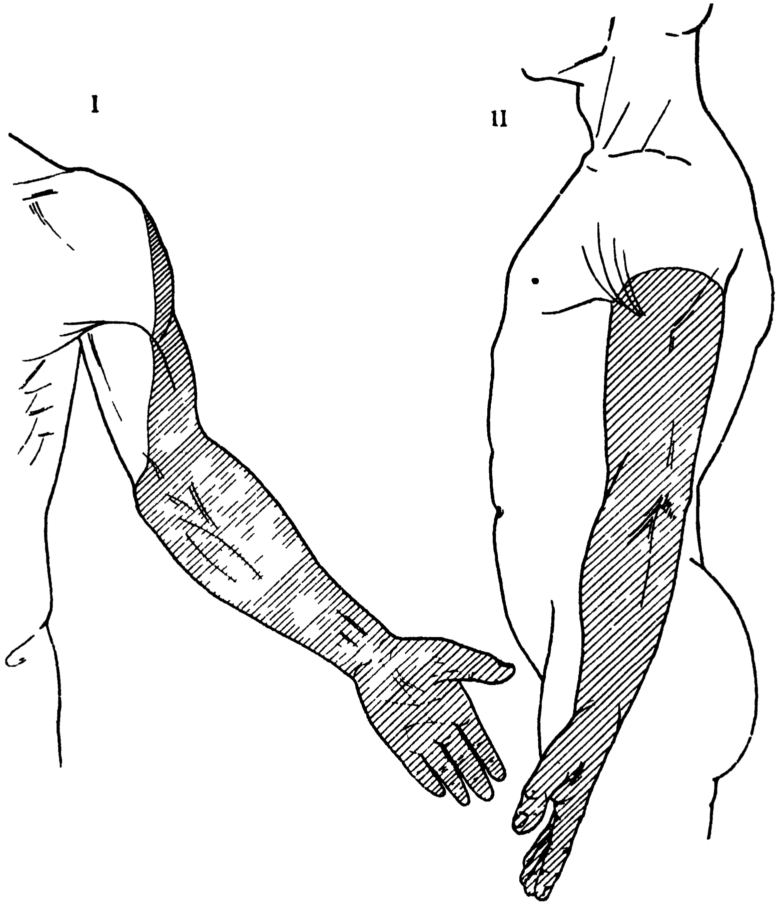


FIG. 186. Loss of protopathic and epicritic sensation following a total division of the brachial plexus.

p. 375). Complete brachial plexus lesions are usually due to the patient being thrown over the handle-bars of a motor cycle and striking the road violently on the side of the head and shoulder. The limb is useless and generally better amputated.

(*b*) **The Upper Arm Type (Erb-Duchenne Paralysis).** This is the most common form and is due to injury of the fifth nerve together with the whole or part of the sixth nerve. It frequently occurs in the form of a brachial birth palsy in the child as the result of a severe labour, the head being overstretched during delivery. In this case it is the most common on the left side and may be seen after either breech or vertex presentations. Traumatic cases are usually due to hyperextension or flexion of the head leading to tearing or stretching of the nerve roots, or to heavy falls on the shoulder which depress its point as occurs in motor cycle accidents.

The deltoid, supra- and infra-spinatus, biceps, brachialis anticus, coracobrachialis, and the supinator muscles are all paralysed and flaccid. Usually in addition the upper part of the pectoralis major, the rhomboids, the subscapularis, teres minor and the latissimus dorsi are involved. Occasionally the radial extensors of the wrist are also paralysed. Thus the patient cannot supinate the forearm, flex the forearm, abduct the upper arm, or rotate the shoulder outwards. The movements of the hand and fingers are unaffected. The result is that the limb takes up a typical position, the arm and forearm being internally rotated and hanging close to the side with the hand pronated, and the elbow extended. Some slight flexion of the forearm may be possible when the hand is fully pronated, being then produced by the extensors of the wrist. There is little loss of sensation, such as there is being confined to the area supplied by the fifth root, and there will sometimes be paræsthesia and tingling sensations in this area, while pressure above the clavicle will be painful. In the later stages subluxation of the shoulder joint may occur from the stretching of the muscles. It will thus be seen that the condition somewhat closely resembles an injury to the circumflex nerve, but in this case the flexors of the elbow are not affected.

(*c*) **The lower arm type (Klumpke's paralysis)** is due to a lesion chiefly affecting the first dorsal nerve, and sometimes the eighth cervical also. All the small intrinsic muscles of the hand are paralysed, so that the hand becomes claw-shaped, the sympathetic fibres to the eye are also paralysed (see p. 357), while the anæsthesia involves the greater part of the inner side of the arm and forearm. The sensation of the hand is little affected, but it must be remembered that this being a root lesion, the area of protopathic loss will be greater than the area of epicritic loss. This lesion is also seen in the form of a birth injury, or may follow various accidents, when it is usually the result of forced elevation of the arm above the shoulder. Both these forms of paralysis will occasionally be the result of poliomyelitis of the anterior horn cells.

Another group of injuries of the brachial plexus consists of those which affect only one cord, the inner, the outer, or the posterior. These are sometimes known as *infraclavicular* injuries, and are most commonly seen as the result of dislocations of the shoulder or attempts to reduce it, or of fractures of the upper end of the humerus or of the scapula, the nerve cord being compressed rather than torn.

(1) **Inner Cord.** This is the cord most commonly affected. Such a lesion leads to paralysis of all the intrinsic muscles of the hand and the muscles of the forearm supplied by the ulnar nerve; the result is a claw hand. There is anæsthesia over the inner surface of the arm, forearm, and the ulnar portion

of the hand. The physical signs of this lesion vary considerably, as the injury is usually incomplete.

(2) **Outer Cord.** A lesion of this is rare, but when it occurs it gives rise to paralysis of the biceps, brachialis anticus, coraco-brachialis and the flexors of the wrist and fingers supplied by the median nerve ; the intrinsic muscles of the hand supplied by this nerve escape. There will be anæsthesia of the outer border of the forearm and radial portion of the hand. If the lesion is very high up the suprascapular nerve supplying the supra- and infra-spinatus muscles may be affected.

(3) **Posterior Cord.** This is also rarely injured. Such a lesion will give rise to paralysis of the subscapularis, the deltoid, triceps, teres major and minor and the muscles supplied by the musculospiral nerve. Anæsthesia is not marked, being confined to a small area on the outer surface of the upper arm and proximal portion of the forearm.

With regard to the diagnosis of brachial plexus injuries, the following points must be observed :—

1. Paralysis of the rhomboids and serratus magnus points to a lesion high up (*i.e.*, near the spine) and in the upper part of the plexus ; involvement of the sympathetic to a lesion high up, but in the lower part of the plexus. If the sympathetic is affected it shows that the lesion is so near to the spinal cord that there is no possibility of surgical approach to the injured nerve above the lesion.

2. The grouping of the paralysed muscles and the sensory changes correspond to no individual single peripheral nerve.

3. Lesions of the spinal cord in this neighbourhood will cause sensory changes on the other side of the body and physical signs in the legs also.

Treatment. The first essential is, if possible, to remove any obvious cause for the lesion, such as pressure from callus, displaced bone, etc. If this cannot be done, or if the lesion is due to some other injury, expectant measures must be adopted for a week or two until it is certain whether the injury of the nerves is complete or incomplete ; it can be determined to be a complete lesion only when the reaction of degeneration has set in. Expectant measures consist in fomentations to relieve pain, massage, and electrical treatment to paralysed muscles and, above all, complete relaxation of any muscles which are paralysed by suitable splintage and posture. As long as the reaction of degeneration is absent operation may be delayed up to a period of two months, but if by then there are no signs of recovery exploration is advisable, whether the reaction is present or not, while directly the reaction of degeneration appears operation should always be performed and an attempt made to restore the continuity of the nerves.

In order to obtain access to the nerves, if the upper part of the plexus appears to be injured, a curved incision is made down the posterior border of the sternomastoid and turning out parallel to and above the clavicle ; the nerves are then found emerging between the scalene muscles. The lower part of the plexus is reached by dividing and subsequently suturing the pectoralis major, while in the case of the first dorsal nerve and middle portions of the plexus it may be necessary temporarily to divide the clavicle. The injured spots are then found, the nerves freed, trimmed and sutured, and the usual after-treatment persisted in (see p. 335) The lower the lesion is, the more favourable the prognosis. Many cases, especially of the Erb-Duchenne type, recover without operation ; in cases in which operation is required it can be predicted confidently that complete recovery will never occur.

Brachial birth palsies in infants are not uncommon, and the condition is often not recognised until some weeks after birth. It is usually due to an overstretching of the nerves, and is nearly always of the upper arm type and accompanied by tenderness in the supraclavicular region, this often being the first and only thing noticed. It may occur in either vertex or breech presentations, but is seen only in severe and prolonged labours. The majority of these cases will recover spontaneously if the arm is rested with the paralysed muscles relaxed for the greater part of the day and in the intervals massage and passive movements indulged in. The reaction of degeneration is difficult to test in a child, but if it is present operative exploration will have to be undertaken.

It must not be forgotten that this condition may be simulated closely by the pseudo-paralysis of the arm seen in infants and due to epiphysitis (see p. 556).

The Long Thoracic Nerve (Nerve of Bell). This nerve supplies the serratus magnus (anticus) and is occasionally injured in extensive operations for carcinoma of the breast; in other instances it may be damaged by a blow on the back of the neck or in those people who are in the habit of carrying heavy weights upon the shoulders, while lesions of it have occurred when the arm has been extended above the head under an anæsthetic. In these cases it is usually found that in addition to the serratus being paralysed, the lower part of the trapezius and the rhomboid muscles may be involved, their nerves being also damaged. The characteristic feature of any injury to this nerve is a **winged scapula,** where the vertebral border and lower angle of the bone are more prominent than on the sound side, the spine is more horizontal, and the lower angle nearer the midline. When the patient attempts to push forwards against an object this deformity is increased and the scapula stands out prominently, while there is difficulty in raising the arm above the shoulder in front of the body, and in performing pushing movements. When the serratus magnus only is paralysed, as in post-operative cases, this deformity and disability are less marked.

Slight "winging of the scapula" also occurs when the lower part of the trapezius is paralysed; in this case, however, if the serratus magnus is unaffected, the deformity becomes less instead of greater when the arm is pushed against a wall, etc.

Treatment. In the cases where the nerve has been damaged during an operation in the axilla the injury is probably complete, and the reaction of degeneration will develop. The ends of the nerve should then be sought and sutured, if this has not already been done at the time of the injury. In other instances, where the condition is due to a subcutaneous injury, spontaneous recovery will almost certainly occur if the limb is placed at rest and supported so as to relax the paralysed muscles while massage and electrical treatment are given.

If all else fails the humeral attachment of the lower costal portion of pectoralis major should be detached and inserted into the lower angle of the scapula.

The Circumflex Nerve. This nerve is occasionally injured where it winds round the neck of the humerus by blows upon the shoulder, fractures of the surgical neck of the humerus, subglenoid dislocations of the shoulder, fractures of the neck of the scapula or the pressure of a crutch. It is sometimes injured by direct pressure upon it in miners who work lying upon their sides, while it may become secondarily involved by callus, due to near-by injuries, or by diseases of the subdeltoid bursa. It must be remembered, however, that in the majority of the cases in which an injury near the shoulder causes paralysis of the deltoid, it is the fifth cervical root and not the circumflex which is injured.

A circumflex injury leads to paralysis of the deltoid and teres minor muscles, so that the deltoid wastes, the acromion becomes prominent, the shoulder flattened, and the patient cannot raise the arm from the side. In old-standing cases the patient may learn to perform this movement with the help of the supra- and infra-spinati and the upper fibres of the pectoralis major. There is usually a small loss of sensation over the insertion of the deltoid and the posterior axillary fold, but this may be difficult to detect. It must be remembered in this lesion that the supra- and infra-spinatus muscles do not waste; this, together with the fact that the anæsthesia is usually more marked, will distinguish the lesion from one of the fifth cervical root.

Treatment. The fact that other muscles learn to perform the movements of the deltoid usually renders an operation on the nerve unnecessary. There is, however, no reason why it should not be sutured in suitable cases.

The Suprascapular and Musculo-cutaneous Nerves are rarely injured. The former may be bruised and injured above the shoulder, which condition leads to paralysis and marked wasting of the supra- and infra-spinatus muscles. There is difficulty in abducting and externally rotating the arm, which is, however, only partial and soon compensated for by other muscles, so that operation is not required.

An injury of the latter nerve causes paralysis of the coraco-brachialis, of the biceps and half of the brachialis anticus. The forearm can, however, still be flexed by the remaining portion of the brachialis anticus, assisted by the supinator longus and radial extensors of the wrist, while the supinator muscles will still supinate the forearm. Anæsthesia will be found over the outer side of the forearm as far as the ball of the thumb

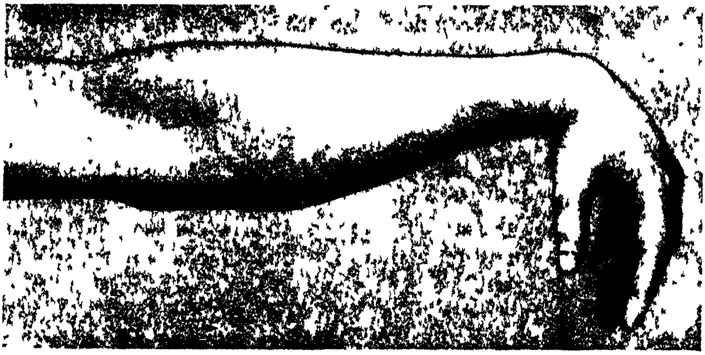


FIG. 187. "Wrist drop" resulting from an injury of the musculospiral nerve.

The Musculospiral (Radial) Nerve. Injuries of this nerve are frequent and of very great importance. Fractures of the shaft of the humerus, especially with communition, frequently cause grave and total lesions of this nerve, the nerve either being torn by the fragments at the time or later involved in and compressed by the resulting scar tissue and callus. It may be compressed against the bone by blows, by a crutch, or by falling asleep with the arm lying over the back of a chair (drunkard's palsy, Saturday night paralysis), and by the pressure of the edge of an operating table when the patient is anæsthetised; also by pressure from the head of the humerus when, under an anæsthetic, the patient's arms have been raised too high above the head. Dislocations of the shoulder and the too tight application of a tourniquet also may damage this nerve. In most of the foregoing injuries the injury is high up and only partial, so that spontaneous recovery occurs.

Crutch palsy can be completely avoided by the use of modern crutches, such as elbow crutches. This nerve is also particularly liable to be affected by the forms of peripheral neuritis seen in lead poisoning and other forms of toxæmia.

Clinical Features. As in the case of other nerves, it is impossible till a few days after the injury to say whether the lesion is complete or partial.

(*a*) Motor Effects. The chief symptom is a dropped wrist, all the extensors of the wrist, thumb and fingers and the supinators being paralysed, so that the wrist hangs flexed and pronated and cannot be extended; in the later stages subluxation of the wrist may occur. If the lesion is high up the triceps and anconeus will also be paralysed, so that active extension of the forearm cannot be performed. Although the supinators are paralysed, supination can still be performed by the biceps. The fingers hang limp and motionless, and are sometimes flexed into the palm of the hand by the unopposed flexor muscles. If, however, the wrist and first phalanges of the fingers are extended and supported, extension of the second and third phalanges is possible by means of the interossei and lumbrical muscles (see p. 366). In addition it often will be found that the whole hand and arm seem weak; the grasp is especially weak, as the flexors cannot be tightened by extending the wrist joint.

(*b*) The anæsthesia produced will be very variable. If the nerve is divided high up in the arm above the spot where its external cutaneous branch leaves it, there will be anæsthesia on the back of the hand in its radial half. But if the lesion is below this spot probably no loss of sensation will be detectable. Similarly it is found that a complete lesion of the radial nerve in the upper half of the forearm causes no detectable anæsthesia, there being no

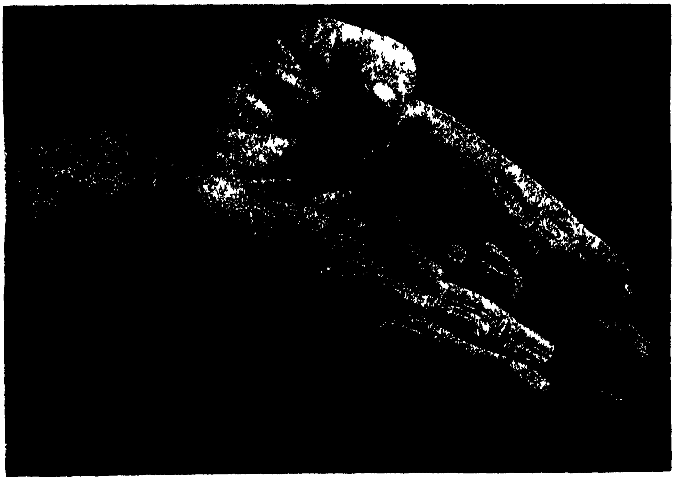


FIG. 188. Median paralysis. An attempt to produce opposition of the thumb only flexes and adducts it. Marked wasting of the thenar eminence is present.

area of skin on the back of the hand which is supplied by this nerve and this nerve alone. Strangely enough, a section of the radial nerve in the lower third of its course will cause a small area of anæsthesia over the back of the thumb, the nerve having here been joined by certain important anastomosing sensory fibres from the musculo-cutaneous and other neighbouring nerve trunks. The radial and **posterior interosseous** nerves are liable to be damaged in dislocations of the head or fractures of the neck of the radius, and operations in this region may also cause damage to the nerves. In this case all the muscles supplied by the posterior interosseous branch will be paralysed. It should be noted that in cases due to lead poisoning the supinator longus muscle almost always escapes, while in the lesions due to crutch, anæsthetic, or " Saturday night " pressure, the sensory changes are very indefinite. These latter lesions, being usually only partial, almost always recover completely without operation, and the prognosis of musculospiral nerve injuries in general is better than that of any other nerve in the body.

Treatment. Operation should not be advocated until it is certain that the injury of the nerve is complete, as shown by the presence of the reaction of degeneration. It is absolutely essential to prevent stretching of the paralysed muscles as soon as possible, by placing the hand and fingers in a position of hyperextension on a cock-up splint, and this must be maintained continuously until voluntary dorsiflexion reappears. Massage, douching, and electrical treatment are then carried out for some days, until it is certain whether the injury is complete or not or until any septic wound which is present is healed. In the case of a gunshot wound sepsis may be severe, and a long time will have to elapse before operation on the nerve really can be considered safe. If the reaction of degeneration sets in or there are no signs of improvement after six weeks, operation should be undertaken at once, the nerve being explored at the site of the injury, and set free from callus or scar tissue as the case may be, or if completely torn, the ends must be sutured.

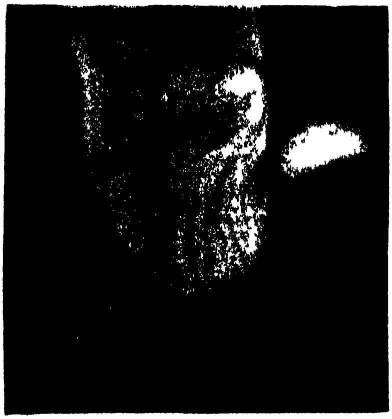


FIG. 189. True abduction of the thumb.

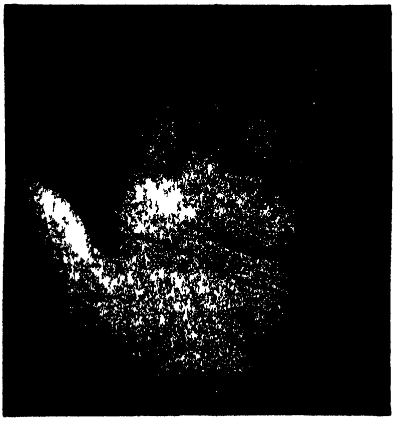


FIG. 190. False abduction of the thumb when the median nerve is paralysed.

If the ends cannot be brought together, both ends may be transplanted to the front side of the humerus, or, failing this, the bone may be shortened or nerve grafting employed. Should it be desired to use an autogenous nerve graft, a portion of the radial nerve should be excised and used. After the operation the nerve should be wrapped round, as far as possible, by a pad of muscle, fascia, or fat, while massage, electrical treatment and splints must be adopted until recovery is complete.

The prognosis of operations on the musculospiral nerve is good; many cases recover spontaneously, while if the nerve is operated on the results are better than those in the case of any other nerve in the body, except possibly the external popliteal, owing doubtless to the fact that it is largely a motor nerve and only controls comparatively coarse and unskilled movements.

It will be found in practice that the only cases likely to require operative exploration are those where the lesion is due to a fracture of the humerus. In these cases it often will be wise to combine the nerve suture with some form of internal fixation of the fracture at the time of the operation.

In those cases where operation fails or cannot be performed, so that complete paralysis persists, other operations upon the muscles and tendons which extend the wrist and fingers or arthrodesis of the wrist joint will lead to great improvement.

Tendon Transplantation. One operation consists in detaching the tendon of pronator radii teres and grafting it into the lower ends of the radial carpal extensors by means of a short incision along the outer border of the forearm; while at the same time the tendons of flexor carpi ulnaris and radialis are grafted into the extensor tendons of the thumb and fingers; for this part of the operation a horse-shoe, flap-shaped incision, over the back of the carpus and convex downwards, is employed.

Alternative operations are (*a*) permanent shortening of the extensors of the wrist to keep the hand dorsiflexed.

(*b*) Fixing the wrist in dorsiflexion by a strip of fascia attached to the radius and metacarpal bones.

(*c*) Grafting flexor carpi radialis to extensor communis digitorum by passing its tendon through the pronator quadratus and joining the palmaris longus to the extensor pollicis longus.

Internal Cutaneous Nerve. This is a purely sensory nerve, and complete division of it causes loss of sensation over the back and front of the ulnar half of the forearm. As this nerve crosses the median basilic vein superficially it is liable to injury in transfusions or injections into this vein. No treatment is usually required, though the nerve can be sutured easily.

Median Nerve. This is a nerve which is very commonly injured, usually by cuts on the front of the wrist, often due to broken glass, bottles, pushing the hand through windows, etc. In this situation it frequently happens that other important structures on the front of the wrist, such as the ulnar nerve, the ulnar or radial arteries, or any of the tendons, are divided at the same time. It may be divided by wounds, especially gunshot wounds, in any other portion of the arm and may be injured in fractures of the lower end of the humerus, the shaft and neck of the humerus, or occasionally in dislocations of the shoulder. It has sometimes been injured in fractures of the radius and ulna or been pressed on by aneurysms. Injuries of this nerve are of great importance, as they lead to great disability of the hand.

Clinical Features. These will depend upon the level at which the nerve is injured.

1. If completely divided just above the wrist, the paralysis and anæsthesia are as follows:—

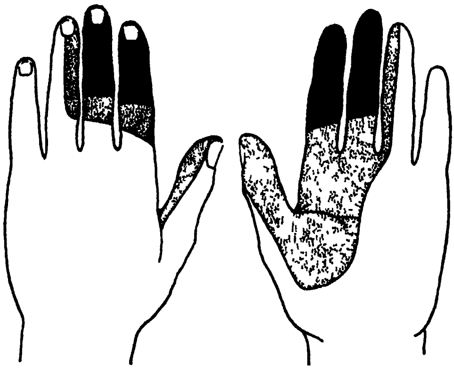
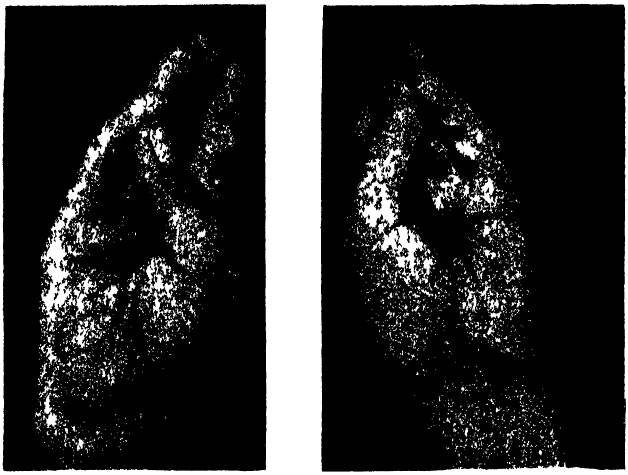


FIG. 191. Loss of sensation after division of the median nerve. Black portion = protopathic loss; shaded portion = epicritic loss.

(*a*) The following muscles are paralysed: the abductor, opponens and outer half of the flexor brevis pollicis, the outer two lumbrical muscles, and occasionally the first interosseous muscle. The result of this is that there is wasting of the thenar eminence, and there is loss of the movements of opposition and abduction of the thumb, the thumb tending to fall back in the same plane as the fingers, as is the case in the hand of the ape. These movements are best tested by asking the patient to swing the thumb and the ball of the thumb forward and inward in order to make the tip of the thumb touch the tip of the little finger. It must be remembered that abduction and opposition of the thumb may be imitated to a certain degree by other muscles supplied by other nerves, such as the long extensors and the long flexor, and care must therefore be taken not to mistake this false abduction and opposition for the genuine movement. In addition to this, the lumbrical paralysis may cause loss of flexion at the metacarpophalangeal joints of the first and second fingers. The hand sometimes will take up a characteristic posture, in which the thumb falls back and the first and second fingers are slightly flexed and claw-like.

(*b*) When the median nerve is divided in this situation, deep touch will be unaffected over the whole area supplied by the nerve unless some of the tendons are also divided. There will be an area in which epicritic sensation



A. B.

FIG. 192. A. Normal opposition of thumb. B. Attempted opposition of the thumb when the median nerve is paralysed.

is completely lost, corresponding roughly to the skin distribution of the median nerve as shown in the diagram. This area will vary slightly, according to the amount of overlap that is present from the ulnar nerve. The area of loss of protopathic sensation will be considerably smaller than this epicritic area and will vary considerably in different cases. It is in this area that the trophic lesions are especially likely to be seen.

2. If the nerve is completely divided in the upper arm or at the elbow, the anæsthesia produced is the same as that described above, while, in addition, the sense of deep touch may also be affected over a smaller area. The same muscles as those described above are also paralysed, and, in addition, the following: pronator quadratus, pronator radii teres, flexor carpi radialis, flexor sublimis digitorum, palmaris longus, and the radial half of flexor profundus digitorum. Thus, in addition to the paralyses described above, in this case there will be very feeble pronation, impaired radial abduction of the hand, and diminished power of flexion of the first and second fingers. The terminal phalanx of the thumb cannot be flexed, and this is well illustrated on asking the patient to clench his fist when the thumb cannot be flexed over the knuckles of the fingers. The index usually cannot be flexed at all except possibly at its metacarpophalangeal joint.

If the median nerve is injured in the upper part of the forearm the clinical features will be intermediate between the two extreme types described above.

In all these injuries, after a few weeks, there may be considerable interference with the mobility of the hand and fingers, partly as the result of adhesions in the joints and round the tendons, while in other cases it is due to the fact that the tendons may be injured or bound up in scar tissue in the forearm.

Deep touch being unaffected in most cases, the anæsthesia is often missed on examination, and the amount of the paralysis being small, many cases of median injury are not diagnosed.

It must be remembered that the median nerve (especially in incomplete lesions) is especially liable to be involved by the distressing symptom of *causalgia* (see p. 338).

Treatment. It is of great importance to prevent deformity by proper splintage, and the rest of the treatment is carried out on the general principles described on p. 334. If the injury is complete, operation must be performed, and the nerve may be found completely divided, in which case it will be sutured, or bound up in scar tissue, when it will be freed. There is usually no difficulty in bringing the ends of the nerve into apposition, however great the gap, as by flexing the wrist and elbow the nerve ends can be stretched towards each other a great deal. The prognosis with regard to recovery in the median nerve is bad, and it is certain that however skilfully it is treated only a very limited amount of recovery will occur; this is chiefly due to the fact that this nerve is a mixed nerve which conveys the most delicate sensations and controls the most fine and delicate movements. The operation is always worth undertaking, however, as a complete lesion of the median nerve renders the hand almost completely useless, and even a small amount of recovery is worth obtaining. Little can be done for this lesion by means of tendon transplantation.

The Ulnar Nerve. This nerve is also frequently injured in accidental wounds with glass, etc., just above the wrist or in wounds at higher levels. It may be damaged in fractures of the inner condyle of the humerus, or of the olecranon or in dislocations of the elbow or shoulder. It has been divided in the operation of excision of the elbow joint, while it may be pressed upon by callus or by the use of a crutch. Severe blows on the nerve at the back of the elbow joint are not infrequent. When it is divided at the wrist it is quite likely that the median nerve and important tendons and arteries will be severed also.

Clinical Features. These will vary according to the level at which the nerve is injured.

1. If this nerve is divided just above the wrist, the short muscles of the little finger (opponens, abductor and flexor brevis), the adductor transversus and adductor obliquus pollicis, the deep portion of flexor brevis pollicis, the palmaris brevis, the two inner lumbricals and usually all the interosseous muscles, will be paralysed. Thus there is wasting of the hypothenar eminence, of all the interosseous spaces and especially of the space between the thumb and index, and the following movements cannot be performed: flexion of the metacarpophalangeal joints of the fingers, abduction and adduction of the fingers (though this may be imitated by the long flexor and extensor muscles if the fingers are not held in full extension), and adduction of the thumb, it being impossible for the patient to grip a pencil or sheet of paper between the thumb and the side (not the front) of the index finger. The paralysis of the lumbricals results in the metacarpophalangeal joints becoming hyperextended and the other finger joints slightly flexed, this posture being present only in the third and fourth fingers (*main en griffe*).

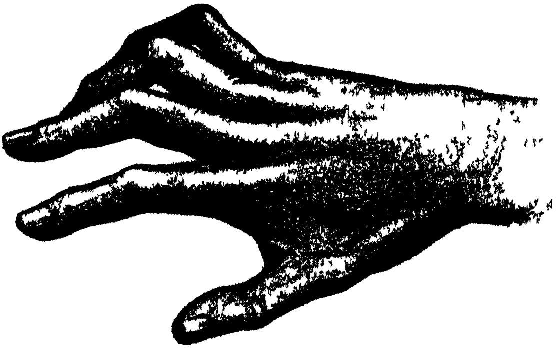


FIG. 193. "Ulnar hand" due to a lesion of the ulnar nerve, showing the characteristic "griffe," the tapering fingers due to trophic changes, and the wasting in all the interosseous spaces

The sensory changes in this condition are as follows: the sense of deep touch will not be affected unless tendons are divided as well.

(*a*) If the nerve is divided above the point at which its dorsal branch is given off, there will be loss of epicritic sensation on the ulnar side of the wrist and of the front of the palm, on the ulnar side of the back of the hand, and of both the back and the front of the little finger and the ulnar half of the ring finger, while protopathic sensation is lost over an area which is always smaller than this but which varies considerably in different cases

(*b*) If, however, the nerve is divided lower down, below the point where its dorsal branch is given off, the sensory changes are much less marked and only involve the palmar aspect of the ulnar half of the hand, the palmar aspect of the little and half the ring finger, and just the dorsal aspect of the terminal phalanges of the same fingers (see Fig. 194).

2. When the nerve is divided in the upper arm or at the elbow the paralysis and changes in sensation will be as follows :—

(*a*) All the muscles above mentioned are paralysed, and in addition the flexor carpi ulnaris and the inner half of the flexor profundus digitorum will be paralysed, with the result that flexion of the wrist and ulnar adduction are weak and the grasp of the hand is weakened. The claw-like deformity is even more marked, the first two fingers being extended and the third and fourth fingers being hyperextended at their metacarpophalangeal joints. All the other joints of the fingers are flexed, this being especially so in the case of the third and fourth fingers. When the wrist is flexed the hand tends to tilt to the radial side. It must not be forgotten that adduction of the thumb may be imitated by other muscles and that the presence of slips connecting

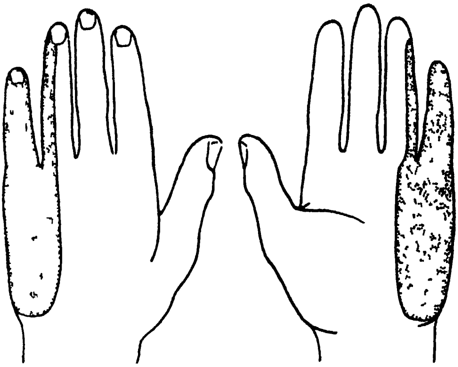


FIG. 194. Loss of sensation after division of the ulnar nerve above its dorsal cutaneous branch.

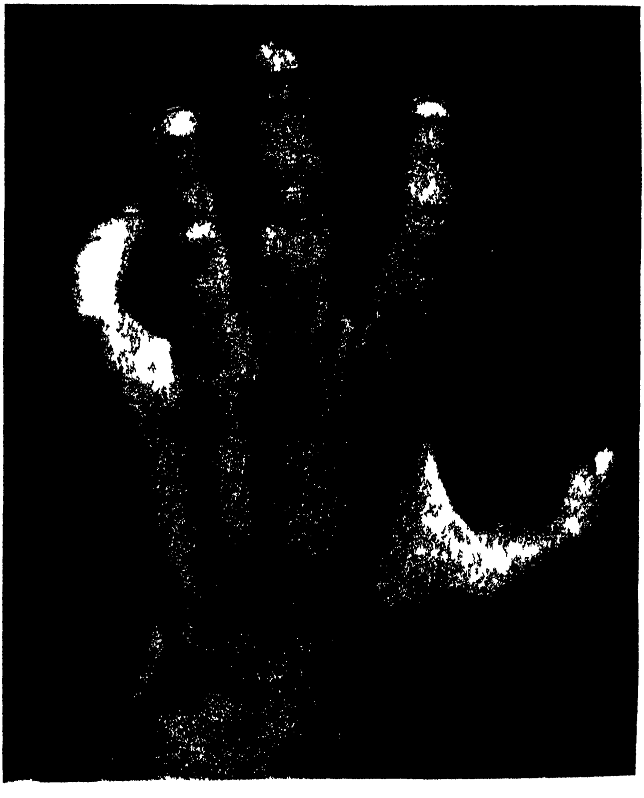


FIG. 195. The "ulnar hand," showing the characteristic claw-hand resulting from a complete lesion of the ulnar nerve, with flexion of the fingers and wasting of all the interosseous spaces, especially the first one.

the flexor sublimis and flexor profundus tendons may permit of a small amount of flexion of the third and fourth fingers.

(*b*) The changes in sensation are the same as those described above when the nerve is divided at the wrist above the point where its dorsal branch leaves it, while in addition there is usually some loss of the sensation of deep touch.

Considerable additional disability will be present in many cases owing to the presence of adhesions around the tendons and joints or to the existence of scar tissue.

Lesions of the ulnar nerve may resemble injuries of the first dorsal root and of the inner cord of the brachial plexus; in both of these, however, all the intrinsic muscles on both sides of the hand are paralysed; in the case of the former there is very little anæsthesia, and in the case of the latter injury the anæsthesia extends up the ulnar side of the forearm.

Treatment. Care must be taken by proper splintage to prevent deformity, while the general principles enunciated above must be followed. If suture of the nerve ends is necessary, they usually can be brought together without difficulty by flexing the wrist and extending the elbow. In other instances it will be helpful to displace the nerve from the back to the front of the internal condyle of the humerus. The prognosis of operations on the ulnar nerve is little better than in the case of the median. It is certain that nothing approaching complete recovery ever will occur, for the same reasons as those given in the case of the latter nerve (see p. 363), while the disability of a complete ulnar lesion is almost as great as in the case of the median, and operations for tendon transplantation are of little use.

Combined Ulnar and Median Lesions. These are by no means uncommon, and are due to wounds either above the wrist or more commonly at the inner side of the upper arm. The signs and symptoms are a combination of the features described above in connection with the two separate nerves. The hand is rendered completely useless.

Dislocation of the Ulnar Nerve. In some persons the ulnar nerve as it passes behind the internal condyle of the humerus is abnormally loose and mobile. In these cases it is particularly liable to repeated injuries from blows at this spot, which are not only exceedingly painful, giving rise at the time to intense burning pain in the two ulnar fingers, but may lead after a time to a condition of **ulnar neuritis** at this spot, which will cause the symptoms of a partial ulnar lesion, while the nerve may be felt to be thickened and tender. This abnormal mobility of the ulnar nerve is predisposed to if its groove is shallow, if the internal condyle of the humerus is poorly developed, and if either the conditions of cubitus varus or cubitus valgus are present; in these patients sudden flexion of the joint may stretch the fascia holding the nerve in place, so that the nerve will pass out of its groove and come to lie upon the front of the humeral condyle, where it may remain permanently, though in most cases it thereafter slips backwards and forwards in and out of its groove. During these dislocations there is pain and swelling at the elbow, and tingling and formication down the course of the nerve, while the nerve itself may be felt rolling about under the finger. This condition also is liable to be followed by an ulnar neuritis leading to a partial ulnar paralysis. A similar neuritis is sometimes seen in severe cases of cubitus valgus without any dislocation, and is then thought to be due to long-continued stretching of the ulnar nerve This may not appear for many years.

Treatment. The dislocated nerve is easily replaced, but frequently shifts its position again. In some cases replacing the nerve and fastening a pad over the condyle while the arm is extended will suffice to keep it in place, but in most cases operation will be necessary and be followed by a permanent cure. The nerve is exposed, the groove in the bone deepened with a gouge, the nerve wrapped in a strip of fascia and fixed into the groove by stitching a layer of fascia over it. An alternative and better proceeding is to transplant the nerve in front of the condyle.

The Intercostal Nerves are frequently injured in cases of fractured ribs. Such injuries will give rise to severe intercostal pain, but they do not give rise to any other noticeable disability. *Intercostal neuralgia* is not uncommon and may be very severe. It may be due to chronic neuritis, pressure upon the nerve by tumours or callus or on the nerve roots in fractured spine, spinal caries, aneurysm or osteoarthritis of the spine. In other cases, and especially in elderly people, it is the result of a previous severe attack of herpes zoster (shingles).

The Twelfth Dorsal Nerve is at times involved in a severe neuralgia which gives rise to intense pain in the lower part of the abdominal wall and the buttock, the pain sometimes resembling that due to various forms of intra-abdominal disease. The causes of such a neuralgia are many. It may be of toxic or idiopathic origin, while in other instances the nerve has become involved in ligatures or scar tissue as the result of an operation in the loin to expose the kidney. In other cases it has been thought that the last rib has undergone mild attacks of periostitis as the result, possibly, of abnormal prominence, so that the nerve has become adherent to it. The only cure for this condition is to expose the nerve above the lesion, cut it and avulse its central end.

A similar neuralgia sometimes affects the **ilio-inguinal nerve,** while this nerve may be involved in scar tissue following operations for inguinal hernia.

THE LUMBOSACRAL PLEXUS AND ITS BRANCHES

This is formed by the anterior primary divisions of the lumbar and sacral nerves. A branch from the twelfth dorsal nerve frequently enters into it also. The roots are distributed as follows :—

Second and third lumbar—to the sartorius, iliopsoas, pectineus and adductor longus.

Second, third and fourth lumbar—to the gracilis and adductor brevis.

Third and fourth lumbar—to the obturator externus and quadriceps extensor.

Third, fourth and fifth lumbar—to the adductor magnus.

Fourth and fifth lumbar and first sacral—to the glutei, semimembranosus, popliteus, quadratus femoris and inferior gemellus.

Fifth lumbar and first sacral—to the flexors of the toes, tibialis posticus and abductor hallucis.

Fifth lumbar and first and second sacral—to superior gemellus, obturator internus, soleus, semitendinosus.

First and second sacral—to pyriformis, gastrocnemius, the interossei and adductores hallucis.

First, second and third sacral—to the biceps and extensors of the toes.

Fourth and fifth lumbar, and first and second sacral—to tibialis anticus and the peronei.

The cutaneous supply of these roots is shown in Figs. 184 and 185.

The roots and cords of this plexus are rarely involved in any lesions in the way in which the brachial plexus is. Gunshot wounds, however, may damage portions of it, while in caries of the sacrum and lower lumbar region, fractures of the pelvis and sacrum, or growths and tuberculous disease of the pelvic bones, pressure upon its nerve trunks may occur. Carcinomata of the pelvic organs, such as the prostate, rectum and cervix uteri, in their advanced stages frequently will involve portions of this plexus.

The Obturator Nerve. This is very rarely injured; such lesions, however, have occurred in anterior dislocations of the hip, obturator hernia and severe labours. These lesions produce paralysis of the hamstring muscles but no anæsthesia. Severe spastic conditions of the adductor muscles often may be relieved by section of this nerve.

The External Cutaneous Nerve. A painful affection of this nerve occasionally occurs, known as **meralgia paræsthetica,** the symptoms of which are pain, tingling, formication or numbness felt in the area of the thigh supplied by this nerve and sometimes brought on by movements or walking; they may be accompanied by sensations of tightness, hyperæsthesia, or even anæsthesia in the same area, while there will be tenderness at the spot just below the anterior superior spine where the nerve passes through the fascia lata. In some cases anæsthesia is the only feature. This disease is rare, but is more frequent in men than in women; it is not known whether it is due to toxic changes or to vasomotor disturbances; in some instances it has been due to the pressure of a truss, while it may be due to the nerve being nipped where it pierces the deep fascia. If rest, baths and electrical treatment produce no improvement, the nerve should be resected.

The Anterior Crural Nerve. Lesions of this nerve are occasionally seen as the result of fractures of the pelvis, gunshot wounds or operations. It is at times affected by peripheral neuritis. The quadriceps femoris is paralysed, while anæsthesia will be found on the inner side of the lower part of the leg near the internal malleolus, and also a small area on the front and inner part of the thigh. The nerve should be exposed and sutured.

The Great Sciatic Nerve. This nerve is frequently involved in injuries due to gunshot wounds, but it is rarely damaged in civilian injuries, except as a result of dislocations of the hip. It is often involved in an intractable form of neuralgia known as sciatica.

Sciatica. In many cases sciatica must be regarded simply as a symptom of some other condition which is causing pressure upon the sciatic nerve or portions of the lumbosacral plexus. This will occur as the result of pressure upon the intrapelvic part of its course or at the sacrosciatic notch, from malignant growths of the prostate, rectum, or uterus, uterine fibroids, the pregnant uterus and sarcomata and osteomata of the pelvic bones; chronic arthritis of the spine will be responsible in some instances. In these cases the pain may be bilateral. In other instances the pressure involves the extrapelvic portion of the nerve, when it may be due to aneurysms, growths of the thigh or femur, old dislocations of the hip and abscesses, especially in connection with tuberculosis of the sacro-iliac joint. In this case the pain is unilateral. Similar pain will occur as the result of involvement of the nerve roots by caries or sarcoma of the spine, prolapse of an intervertebral disc, and certain degenerative diseases of the spinal cord, such as tabes. In true sciatica, however, none of these causative conditions are present, and this primary form of the disease is chiefly met with in adults who suffer from gout, rheumatism, constipation, indigestion or oxaluria. It is then due to an inflammation of the neurilemma, which in addition to the above causes may be the result of injury, syphilis, acute rheumatism, exposure to cold and damp or to unusual articles of diet. It is particularly common in those whose work demands a squatting or cramped position, while it is frequently associated with lumbago and fibrositis in other parts of the body. In the idiopathic or spontaneous forms the nerve often will be swollen, red and tender.

Clinical Features. These consist of severe pain referred all down the course of the nerve in the buttock, and the back of the thigh, leg and foot, while it is not unusual for the pain to be confined to the heel or toes; it may be paroxysmal or continuous and either slight or exceedingly severe. Movement and walking make it worse, as also does any action which tends to stretch the nerve or to produce any pressure upon it. The patient limps and holds himself in a peculiar position, walking on tip-toe with the limb slightly bent, and as far as possible avoids putting his weight on that leg. The tenderness of the nerve when stretched can be demonstrated by laying the patient on his back on a couch and then flexing the thigh on the abdomen as far as possible with the knee bent. On holding the thigh in this position it will be found impossible to straighten the knee. In severe cases, and especially those that are due to a definite neuritis of the nerve, the nerve will be tender to pressure, especially at the points (*a*) where it leaves the pelvis, (*b*) midway between the great trochanter and the tuberosity of the ischium, and (*c*) where the external popliteal nerve lies upon the neck of the fibula. There also may be numbness and anæsthesia over the foot, patches of anæsthesia up the leg, wasting of muscles, loss of deep reflexes, and even vasomotor and trophic changes. The reaction of degeneration is never seen unless severe neuritis has been present for some time. When the condition has been present for months it is often found that as a result of the posture the patient adopts, the pelvis becomes permanently tilted and a definite scoliosis develops. The disease is often particularly obstinate and intractable; it may last for weeks or months and frequently reappears again after apparent cure.

It cannot be too strongly insisted upon that the rectum and pelvis must always be examined in every case of sciatica before such a diagnosis is made. It must be remembered also that in many cases a similar referred pain will be encountered as the result of disease of the spine, either tuberculous or osteoarthritic, or of tuberculous disease of the hip or sacroiliac joints. Cases of bilateral sciatica always strongly suggest the pressure of a pelvic or spinal tumour.

Treatment. The treatment of this condition depends upon the cause and is of two kinds, general and local. Any cause detectable should be eliminated, and the general treatment consists in the administration of antirheumatic remedies, while indigestion, gout and constipation must be treated, and any of the drugs recommended for neuralgia in general may be used; thus aspirin, salicylates and sedatives of this type may relieve the pain, while in some cases it may be so severe that morphia will be required. Potassium iodide and atropin are also beneficial.

In the way of local treatment, in acute cases the patient must stay in bed with hot applications and thermogene wool to the limb, while when the condition becomes more chronic, baths, massage and electrical treatment may be applied. In some cases counter-irritation in the form of painting a wide streak of fuming hydrochloric acid with a brush all down the leg over the course of the nerve from the buttock to the heel will be of benefit. If these measures are not sufficient, the nerve may be needled or normal saline may be injected into it at several places and on several occasions—30 to 50 c.c. being inserted each time. Saline may also be injected extrathecally through the sacral foramina, in sufficient quantity to ensure considerable pressure; this method is often successful in chronic cases, but should not be used in the acute stage as the condition is thus often aggravated. Electrical treatment and spa treatment at various mineral water centres are sometimes helpful.

If these methods fail the nerve may be stretched, but it must be remembered that stretching the nerve is open to a considerable risk of making the condition worse. This stretching may be done by open operation, in which case the nerve is exposed by an incision over its course running downwards from the buttock; the nerve is then lifted up by retractors and forcibly pulled upon, where it emerges from under cover of the gluteus maximus. Considerable force must be used to stretch it satisfactorily, and it should be steadily and not jerkily applied. Before, however, proceeding to open operation it is well to stretch the nerve subcutaneously by placing the patient on his back on a couch and administering an anæsthetic, flexing the thigh upon the abdomen as far as it will come and then forcibly extending the knee.

It has been found empirically that many cases of chronic sciatica are greatly improved by administering iodine in the following way: A 10 per cent. solution of iodine in rectified spirit (without any potassium iodide), this being a fully saturated solution, is administered by the mouth in milk, in doses of 5 minims three times a day the first day, 6 minims three times a day the second day, 7 minims three times a day the third day, and so on till 15 minims three times a day are reached. The dose is then reduced to 14 minims, 13 minims, etc., back to 5 minims three times a day. Though liable to depress the patient and upset his digestion, great improvement often will be caused by this, both in chronic sciatica and also in various chronic rheumatic and osteoarthritic conditions.

Injuries of the Great Sciatic Nerve. These are always the result of gunshot and other wounds, though minor degrees of compression which only last for a short time and soon recover completely are sometimes seen after sitting in constrained attitudes upon hard objects. This nerve is really a double nerve, consisting below the gluteal fold of the two separate nerves, the external and the internal popliteal (see p. 373). Injuries of the great sciatic nerve usually occur below this point, and therefore may be regarded clinically as equivalent to injuries of one or other of these two nerves or both of them. The branches supplying the hamstring muscles leave the nerve above the gluteal fold, and these muscles are not therefore paralysed unless the nerve is damaged near its exit from the pelvis, which is most unusual; even if the hamstrings are paralysed, the leg can be flexed by the gracilis. If a lesion of the great sciatic nerve is incomplete it is far more likely to involve the external popliteal portion than the internal, while incomplete lesions which do involve the internal popliteal portion are very liable to be followed by *causalgia,* consisting of a burning pain in the sole of the foot similar to that seen in the case of the median nerve. A complete division of the great sciatic nerve paralyses all the muscles of the leg, while drop-foot is very noticeable. There is complete loss of sensation of everything below the knee, except in the long saphenous area; the hamstrings are frequently not affected, while the quadriceps muscle is not supplied by this nerve.

Treatment. The treatment is that of nerve injuries in general, special attention being paid to splintage to prevent deformity (chiefly drop-foot), and proper massage and electrical treatment. The question of operation must be decided upon on the general principles enunciated above. There is usually no difficulty in bringing the ends of the resected nerve together if the knee is fully flexed and the hip extended. Great care must be taken to suture the external and internal popliteal segments in proper apposition with each other, so that their fibres correspond. The prognosis of suture of this nerve is fairly good, especially with regard to its external popliteal portion, but complete recovery must not be expected.

In cases where operation cannot be performed or is a failure, and the paralysis persists, a great deal of improvement can be achieved by means of properly fitting apparatus to support the limb, and by such operations as arthrodesis of the ankle and tendon transplantation or fixation. Amputation of the leg is hardly ever necessary, but if the foot is badly nourished and covered with trophic lesions, Syme's amputation may be considered seriously.

The External Popliteal Nerve. This nerve is specially exposed to injury where it lies on the fibula immediately below the head of the bone, and in this situation it may be compressed by bandages, puttees, splints, Clover's crutch or tourniquets, or may be torn by the fragments in fractures of the upper end of the fibula; later it may be involved in callus. Gunshot wounds may involve it, while the orthopædic surgeon may be unfortunate and damage it during tenotomy of the biceps tendon, when excising the head of the fibula or making incisions in this neighbourhood. It has been stated that prolonged severe flexion of the knee may cause paralysis of this nerve, while it is frequently involved in peripheral neuritis.

Clinical Features. In a total division, the tibialis anticus, the extensor muscles of the ankle and toes and the peroneal group are completely paralysed. The foot drops down and cannot be dorsiflexed, and the toes cannot be lifted off the ground in walking, while later, contraction of the flexor muscles will give rise in cases which are not properly treated to a severe talipes equinovarus. The anæsthesia depends upon how high the nerve is divided; it always involves the greater part of the dorsum of the foot and also will affect the lower part and outer side of the leg if the nerve is divided above the origin of its large cutaneous branch.

Lesions of the nerve will resemble closely those of the fifth lumbar root, but in the latter condition the tibialis anticus muscle escapes paralysis, while the sensory changes are slightly different.

Treatment. This is conducted in accordance with the general principles already enunciated, and in most cases the nerve will require suture, while the ends usually can be approximated easily by flexing the knee and dorsiflexing the foot. The prognosis of suture of this nerve is very good—almost as good as in the case of the musculospiral nerve, and for the same reasons (see p. 360). The foot must be kept in dorsiflexion by proper splintage in order that the extensor muscles may not become stretched, and walking is easy with an apparatus with a toe-raising spring. If for any reason operation cannot be performed or it fails and the paralysis persists, tendon fixation, employing the tibialis anticus and the peroneus longus tendons, will be beneficial in correcting the foot drop, while tendon transplantation generally will be useful and achieve the same object.

The Internal Popliteal Nerve. This nerve is rarely injured as it is far less exposed than is the previous nerve; it is sometimes damaged in forced extension of a fixed flexed knee. In a complete lesion all the calf muscles are paralysed, including the plantar flexors of the ankle, the flexors of the toes and also the short muscles of the sole of the foot, so that after the lesion has been in existence for some time a paralytic talipes calcaneovalgus probably will develop, with a marked tendency to pes cavus. The anæsthesia in this case comprises the greater part of the sole of the foot, the plantar surface of all the toes and the dorsal surface of all the outer four toes. In an incomplete injury this nerve is particularly liable to develop a causalgia (see p. 338).

Treatment. The general principles of treatment are the same as in the case of other nerves, and in most cases operation will be necessary. It will be found that the nerve ends generally can be brought together easily if the knee is flexed and the ankle is plantar-flexed. The prognosis as to recovery after suture is poor, but luckily paralysis of this nerve does not lead to great disablement.

The Anterior and Posterior Tibial Nerves are occasionally divided, being damaged usually either by gunshot wounds or by being involved in fractures of the tibia and fibula. The signs and symptoms of these injuries will be very similar to those associated with injuries of the external and internal popliteal nerves respectively, only they will be far more limited and will depend upon the level at which the nerves are divided. A lesion of the anterior tibial nerve results in a talipes equinus with some foot-drop and extensor paralysis according to its level, while paralysis of the posterior tibial nerve leads to paralysis of the intrinsic muscles of the sole of the foot and some of the long flexors of the toes according to the level, the condition being liable to result in a talipes calcaneovalgus with a tendency to pes cavus. The treatment of injuries of these nerves is similar to those of other nerves.

THE SPINAL NERVE ROOTS

(For the surgical anatomy of the spinal nerve roots, see p. 326.) After leaving the spinal theca and passing through the intervertebral foramina the nerve roots pass through various plexuses, being split up and reunited in various ways and finally come to form the peripheral nerves, almost all of which therefore are derived from several nerve roots. The sensory areas corresponding to the different nerve roots are arranged therefore in a fashion very different to the areas which correspond to the individual peripheral nerves, and these sensory nerve root areas are illustrated in the diagrams on pp. 354 and 355. It must be remembered :—

(*a*) That a considerable amount of sensory overlap is present, and (*b*) that in the case of an injury to a nerve root, the area of protopathic loss is greater than the area of epicritic loss. It will be found also that individual muscles and muscle groups are nearly always supplied by more than one spinal root, though in many cases they may derive their principal supply from one root.

In the case of lesions of the cauda equina (see p. 369) we are dealing with nerve roots, and this is the commonest situation in which root lesions occur. They are described in Chapter III., Vol. II. The spinal nerve roots elsewhere may be involved and pressed upon by many different lesions, such as callus, adhesions, bony deformities or osteoarthritic outgrowths of the spine, aneurysms, gummatous lesions, and tumours of the spinal column or spinal cord. The symptoms of such a lesion consist in neuralgia, which may be intense and accompanied first by hyperæsthesia, while later, if the condition persists, anæsthesia and paralysis of muscle groups will supervene, all the symptoms being confined to the areas and supply of the individual roots concerned.

Division of Posterior Roots. (Forster's Operation.) Intradural division of certain posterior roots is an operation which has been practised for several different conditions and with a varying amount of success ; thus it has been performed for :—

(*a*) The visceral crises and lightning pains of tabes.

(*b*) In the hope of relieving certain spastic conditions of the muscles, especially in the legs.

(*c*) For intense neuralgia which has failed to react to any other form of treatment, and in such conditions as median or internal popliteal causalgia and painful phantom limbs after amputations.

It is by no means certain of success in any of these conditions, for when intense neuralgic pains have been present for a prolonged period, the presence and probability of the pain become so fixed in the patient's psychical centres that it will frequently appear to continue after all possible physical cause for it has been removed. In the case of tabes, only partial success has followed the operation, while in such spastic conditions as cerebral diplegia of children considerable improvement has occurred.

THE SYMPATHETIC SYSTEM

Surgical Anatomy and Physiology. The so-called *autonomic nervous system* is, it must be realised, dependent on the central nervous system, and is controlled by ganglia situated in the lower part of the wall of the third ventricle and upper part of the iter. It consists of two systems in many ways antagonistic to one another, the *sympathetic* and *parasympathetic* nervous systems. The sympathetic chains with their many ganglia, with their grey and white rami communicantes, and the greater and lesser splanchnic nerves situated on either side of the vertebral column, are well known, and for a detailed description the reader is referred to any standard text-book of anatomy. The parasympathetic fibres leave the ganglia of the spinal cord at the cervical and lumbar enlargements, and pass directly to the walls of the viscera of the thorax and pelvis, in which their minute ganglia are situated. The main parasympathetic nerve is the pelvic nerve.

The surgeon is primarily concerned with those portions of the sympathetic system which lie in the region of: (1) the stellate ganglion, (2) the abdominal sympathetic chain, (3) the hypogastric plexus, (4) the pelvic nerves; for it is in these regions that the sympathetic nerve fibres for large areas of the body form localised collections.

1. *The Region of the Stellate Ganglion.* Fibres from this ganglion pass to the head, face and neck, the unstriped muscle of the orbit, the glands of the neck and head and to the upper extremities. These fibres are chiefly vaso-constrictor, pilo-motor and secretory. It also gives off accelerator fibres to the heart and some unimportant fibres to the lungs.

2. *The abdominal chain* gives off similar fibres to the lower limbs and visceral fibres which inhibit peristalsis and increase the tone of the sphincters, these being roughly the opposite effects to those of the vagus and pelvic nerves, although the interaction of these fibres both among themselves and with other nerve filaments coming directly from the bowel render all these actions by no means so simple as this. It also supplies the kidney and ureters *via* the renal ganglion, the fibres running along the renal arteries.

3. *The hypogastric plexus* supplies the internal organs of generation and appears to activate both the secretory and motor powers; it also supplies a portion of the colon and bladder.

4. *The Pelvic Nerves* (*Parasympathetic*). That these supply some parts of the colon seems undoubted, but it is uncertain how far up they go and where the vagus control ends. Probably these fibres do not pass through the hypogastric plexus.

Afferent Fibres. Afferent fibres in the sympathetic system also exist. The rami to the limbs and neck do not seem to contain many afferent fibres, although certain operations on the sympathetic nerves undoubtedly relieve pain, but the nerves to the viscera do however contain afferent fibres which enter the white rami communicantes and pass to the cord in the dorsal roots. Afferent fibres from the heart enter the four upper dorsal roots and can therefore be sectioned either at the stellate ganglion or in the spinal roots. Afferent fibres from the upper abdominal viscera pass up the greater splanchnic nerve and from the kidney *via* the lesser splanchnic nerves. The pelvic visceral afferent fibres pass *via* the hypogastric plexus and pelvic nerves.

It is now thought that some of the spinal nerves and all those of the autonomic system actually produce their effect through the action of certain chemical substances, chiefly adrenaline and acetyl-choline.

The surgery of the sympathetic system has made considerable strides in the last few years. One method of anæsthesia is directed against this system by means of an injection of novocaine into the cœliac ganglia of the abdomen (see p. 800), while a surgical attack has been made upon various portions of the sympathetic system in an attempt to relieve such conditions as angina pectoris, spastic conditions of the limbs, etc. Thus, Royle and Hunter devised the method of section of various rami communicantes connecting the sympathetic system with the brachial and lumbar plexuses in an attempt to relieve certain spastic conditions of the arms and legs ; the operations are easy to perform, but they result in most cases in little or no improvement.

Weakening of vagal impulses and a relative increase of sympathetic inhibition is thought to be a possible cause of such conditions as spasm of the pylorus, visceroptosis and ill-defined gastric pains, and in such cases attempts have been made to get rid of inhibitory sympathetic impulses by dividing nerve fibres in the lesser omentum and gastric wall. The semilunar ganglion and certain of the splanchnic nerves have been excised with a certain amount of success in gastric crises and pyloric spasm.

The amount of sympathetic hypertonicity may be estimated by inducing a rise of temperature in the patient and noting how much vasodilation follows in the part concerned.

Many other abdominal and intestinal conditions have been thought possibly to be due to vagal and sympathetic influences.

(1) Paralysis of both vagal (excitor) and sympathetic (inhibitory) impulses may possibly give rise to acute dilatation of the stomach and paralytic ileus.

(2) Relative paralysis of the vagus or overaction of the sympathetic for all impulses may play a part in causing pain in visceroptosis, and in giving rise to Wilkie's disease (duodenal ileus), enterospasm and colonic spasm.

(3) Relative paralysis of the vagal impulses to the sphincters only probably plays a large part in producing achalazia, pylorospasm and Hirschsprung's disease.

The Cervical and Lumbar Sympathetic. Excision of the whole or parts of the cervical sympathetic with its ganglia has at times been practised for epilepsy, Graves' and Raynaud's diseases (see p. 159), and for glaucoma. The results have been very uncertain, but occasionally much improvement in Raynaud's disease in the fingers has followed excision of the stellate ganglion. Complete sympathetic denervation of the upper limb really requires removal of the inferior cervical and first and second dorsal ganglia. This operation will be followed by Horner's syndrome (see p. 378), but if a preganglionic resection is done this syndrome can be avoided.

Similar benefit has also followed in the leg after excision of the lumbar sympathetic ganglia. Complete denervation of the lower limb requires removal of the second, third and fourth lumbar ganglia.

Removal of the stellate ganglion interrupts vaso-constrictor fibres to the upper limbs and therefore gives a definite increase in blood flow. Inasmuch as even in obliterative arterial disease an element of vaso-spasm is present, marked (though unfortunately only temporary) benefit will occur in a variety of vascular and neuro-vascular conditions in the limbs. The amount of vaso-spasm present can usually be determined by blocking the sympathetic nerves with novocaine.

The foregoing remarks apply equally to section of the lumbar sympathetic chain.

These beneficial results are often seen in Raynaud's disease, thrombo-angiitis obliterans and other forms of obliterative angiitis (if not syphilitic), circulatory disorders following infantile paralysis, erythrocyanosis and erythromelalgia.

Most surgeons are agreed that the results of sympatheticectomy are better in the lower limbs than in the upper, probably because here a preganglionic resection is done while the effects of both vascular disease and of treatment are more marked at the extremities of the limbs. In both limbs, after some months of marked improvement, there is a great tendency for relapse to occur.

Removal of the stellate ganglion may be carried out by either a posterior or anterior route, the latter method being neater and doing less damage. By a flap incision just above the clavicle the ganglion is approached behind the sterno-mastoid and found lying on the neck of the first rib.

The lumbar sympathetic chain is approached retroperitoneally through what is really a large kidney incision. The peritoneum is exposed and lifted forwards, the psoas muscle is seen and finally, and usually easily, the chain is found lying on the side of the vertebral bodies. If both sides are done on the same day, the procedure is best done transperitoneally.

The Abdominal Portion of the Sympathetic. Many operative procedures with varying degrees of success have been practised for different abdominal conditions. The inferior mesenteric ganglion has been excised for pelvic pain in dysmenorrhœa or pain due to rectal and vesical carcinoma. The ganglion is exposed across the peritoneum by means of a low paramedian incision.

Hirschsprung's Disease. Dramatic success often follows the treatment of this condition by various forms of sympathetic section. Section of the pre-sacral nerve by laparotomy, or this procedure combined with the removal of the inferior mesenteric ganglion, seems to have given the best results, and bowels which have never acted before spontaneously have functioned quite well afterwards.

This condition is usually met with in children, but similar operations performed for acquired constipation and intestinal stasis in adults have not been equally successful.

Renal Pain. Periarterial stripping of the sympathetic plexus from the renal artery has been performed for renal pain either of unknown origin, or associated with nephroptosis or early hydronephrosis; in many cases considerable benefit has followed.

In certain vague and less defined conditions such as painful arthritis, hyperidrosis and retinitis pigmentosa, these operations have been performed empirically, and met with varying degrees of success.

Various minor discomforts may follow these procedures; dry, rough or cracked skin on the hands, occasional pain in the shoulder and arms, and stuffiness in the nose are sometimes complained of after cervical sympatheticectomy. After a lumbar or pre-sacral operation, in the male, sterility may follow, though he does not usually become impotent.

The general tendency of all these operations on the sympathetic system would appear to be a distinct temporary improvement usually followed by a relapse after some months.

Paralysis or irritation of the cervical sympathetic. The sympathetic nerve cord in the neck is liable to be injured by gunshot or other wounds and operations deep down in the neck, while certain of its fibres will be involved in affections of the first dorsal nerve root or the lower part of the cervical portion of the spinal cord (see pp. 354, 357). Aneurysms and tumours also will press upon this structure.

If the cord is irritated by minor degrees of pressure there will be dilatation of the pupil, prominence of the eyeball, sweating of the head and pallor of the face all on the side of the injury, while if the cord is completely divided there will be complete paralysis of the cervical sympathetic, as shown by contraction of the pupil, which does not dilate when the light is cut off from it, ptosis and loss of ocular tension, while the eyeball sinks in and the palpebral fissure appears smaller ; this is the result of paralysis of the unstriped orbital muscle ; in addition there are vasomotor paralysis and lack of sweating on the side of the head, face and neck, the upper part of the chest and the whole of the arm, also on the side of the injury. (Horner's syndrome.)

A Neurofibromatous Swelling of the Superior Cervical Ganglion has been described, which gives rise to a firm swelling deep in the neck, behind the carotid vessels; it also causes pain in the eyeball and temple and the signs of irritation or paralysis of the sympathetic cord.

Periarterial Sympatheticectomy. This operation was introduced largely by Jaboulay and Leriche originally to give relief in such conditions as causalgia and brachial neuralgia, and there is little doubt that in many painful vascular conditions of the limbs, such as gangrene of various forms, Raynaud's disease and chronic ulcers, it has beneficial effects, chiefly on the pain. It has also caused marked improvement to indolent ulcers. The operation consists in stripping the main artery of a limb bare of the sympathetic plexus running around its walls for an inch or so. Any vasodilating effect that this procedure has must be in cutting off afferent sensory impulses running up in this plexus, for the vasoconstrictor fibres are not situated here ; the afferent side of the reflex is therefore the one affected. Leriche, who performed this operation many times, formulated two rules which should be observed in all cases :—

(1) Periarterial sympatheticectomy should never be performed in any case where an actively progressive lesion is present.

(2) In all cases the results are transitory, the maximum benefit being manifest three weeks after the operation.

It is obvious, therefore, that in cases of senile gangrene, the only form likely to be benefited by periarterial sympatheticectomy, the amputation will probably still be necessary and should be performed three weeks after the preliminary operation ; experience shows that local removal of the gangrenous area is often successful in these cases.

Temporary benefit has followed this operation in cases of senile gangrene, arteriosclerosis, arterial thrombosis and embolism, thromboangiitis obliterans, and occasionally in diabetic gangrene when not septic or progressive. The spread of the gangrene has been delayed or stopped and, above all, much relief of pain achieved. The operation is usually performed on the common femoral artery, which is exposed for 2½ inches ; the tunica externa is separated from the media and cut away altogether for an inch or so. Great care must be taken not to damage the vessel wall. Some surgeons prefer to inject the plexus with absolute alcohol. This is, however, far less certain in its results.

Essential Hypertension. Recently in many cases of this disease, which consists in a very high blood pressure with all its usual symptoms occurring in a patient, sometimes quite young, who has no organic disease of the heart, kidneys or blood vessels, remarkable relief has been given by sympathetic surgery. A kidney incision is made and by retroperitoneal exposure the cœliac ganglion which is easily found lying on the crus of the diaphragm, two-thirds of the suprarenal gland and the second and third lumbar ganglia are removed. In the female the first lumbar ganglion can be removed too, but in the male it is thought to supply the seminal vesicle and that loss of ejaculation may be caused by its removal.

This operation should be done on both sides, and it is often possible to do both sides on the same day.

CHAPTER XIII

THE MUSCLES, TENDONS AND BURSÆ

Injuries, Diseases and Tumours of the Muscles, Tendons, Tendon Sheaths, Bursæ and Fibrous Fasciæ

These connective tissues are for the most part separated from the superjacent subcutaneous tissue by a dense and well-defined fibrous layer of deep fascia, but inasmuch as this may be divided in an injury and is normally pierced by numerous blood and lymph vessels, infection is very prone to affect these deeper tissues by direct spread from skin or subcutaneous foci. Certain bursæ, moreover, are situated in the subcutaneous tissue, and are thus particularly liable to direct infection, or to spread of infection from adjacent tissues, the more so as their synovial lining and its secretion are very susceptible to infection, which is also the case with the synovial membranes in the tendon sheaths and joints. It will be better, for the sake of clearness in description and classification, to deal separately with the various tissues mentioned, but it must be realised that they are directly connected or lying in close contiguity, so that conditions affecting one type of tissue, *e.g.*, muscle, will in a greater or lesser degree also involve the other tissues, *e.g.*, tendons and tendon sheaths and adjacent bursæ. Thus in an injury to a muscle or tendon there is an effusion in the tendon sheaths, and usually in adjacent bursæ, while in infections of the tendon sheaths there are wasting and disability from involvement of muscles and tendons traversing these; there are frequently effusions into neighbouring bursæ and joint cavities; and, again, where, as in gonorrhœal septicæmia, the main stress of the infection falls on the fasciæ, the involvement of the fibrous intramuscular prolongations of these causes involvement of the muscles, and thence of the tendon sheaths.

MUSCLES, TENDONS AND FASCIÆ

These tissues, though differing widely in microscopic appearance, are so intimately associated both in anatomy and function that they are best discussed together.

Muscle, it will be remembered, is of two varieties, the striped voluntary and the unstriped involuntary, which differ in microscopic appearance according as the protoplasm of the elongated mononuclear muscle cells presents cross stippling or is homogeneous. In the case of the voluntary muscles, these cells are arranged in groups, separated from one another by strands of fibrous connective tissue in which run vessels and nerves, and many of these are aggregated to form an anatomical "muscle," the whole being encased in a fibrocellular sheath continuous with those of adjacent muscles, and with the fasciæ and periosteum of the bones to which they are attached. Such muscles are arranged in groups for the co-ordination of the movements of the various parts of the body, and those in any one group are frequently imperfectly differentiated from each other; which, as they all act in unison and have a common nerve supply, is of no consequence except that, being directly contiguous, affections of any one muscle in a group will pass rapidly and easily to others.

Tendon consists of densely packed masses of elongated cells, and is connected at one end with the fibrous septa between the groups of muscle cells, and at the other blends with the periosteum. In order to facilitate the play of the tendon in the tissues, it usually becomes surrounded by a synovial sheath; and not infrequently at points where friction exists from the tendon working directly on bone, a cartilaginous nodule (sesamoid) develops in the tendon, which may ossify, as in the case of the patella, to form a sesamoid bone.

Fibrous tissue consists of elongated mononuclear cells (fibroblasts) closely resembling those seen in unstriped muscle, interspersed among which are blood vessels, nerves, fat, and lymphatic channels and spaces; according to the proportion of these to the fibroblasts, so does the density of the fibrocellular tissue vary, from scar tissue which is nearly all fibroblasts, through fascia to areolar connective tissue, which may be mainly fat and vessels.

INJURIES

Muscles and tendons may be involved, and even severed, in deep incised wounds, when on attempting to put the affected muscle into use no movement occurs, but the upper portion of the contracted muscle can be detected as a soft lump, with a gap below, which widens during the contracture. In penetrating wounds, such as bullet wounds, the muscles may be much disrupted and extensive hæmorrhage occur in them, with liability in the case of infected wounds to the onset of gas gangrene (Chapter VII., p. 164). Such wounds, therefore, should be explored and cleaned carefully, and all damaged muscle excised. In clean-cut wounds the muscle may be sutured with catgut and the surrounding fascia similarly treated, the wound being closed. It is doubtful if regeneration of muscle ever occurs, a scar persisting in the suture line; end-to-end apposition is therefore very desirable, so as to prevent extensive scarring and disability.

Faradisation, passive movements, and massage should be resorted to immediately in order to prevent wasting, adhesions and stiffness, and early active movements encouraged for the same reason in all cases of injuries to muscles; the only possible exception being in those cases where extensive damage has occurred to the subjacent periosteum, and here only faradism should be resorted to, because of the danger of the occurrence of myositis ossificans (p. 388, and Chapter XIV., p. 410).

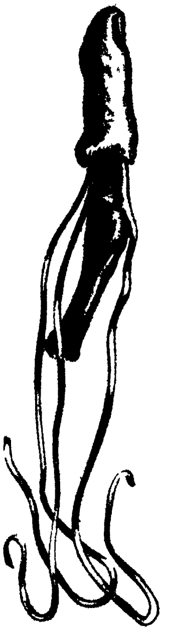


FIG. 196. Avulsed digit, showing length of tendon torn away.

Division of tendons is a more frequent accident, and is commonly seen in wounds in the region of the wrist and fingers, but may occur elsewhere, as around the ankle or knees. It must be remembered that the upper end of the tendon will be drawn up considerably above the wound by the retraction of its muscle, whereas the lower end usually will be visible in the wound itself, unless a fibrous sheath exists, as in the fingers, when the lower end may retract some distance into this; furthermore, other important structures in the neighbourhood, such as nerves and blood vessels, may be injured. All such wounds, therefore, should be explored very carefully immediately and every care taken to cleanse them so as to prevent infection by septic organisms, if possible (Chapter IV., p. 41). The part moved by the tendon is, of course, motionless when the affected muscle is put into action, and, moreover, owing to the unopposed action of the opposing muscles, it will be held in an extreme position from over-action of these, *i.e.*, if the flexor tendons to the finger be cut the affected digit is hyperextended. It must be remembered that damage to the nerve supply to a muscle will give a similar paralysis (Chapter XII., p. 329), but here attempts to contract the affected muscle do not result in any hardening of the muscle belly.

The *treatment* consists in immediate and thorough exploration of the wound under anæsthesia, with excision of damaged tissue and thorough cleansing; vertical incisions may be necessary to expose the retracted upper ends of cut tendons. Suture should be carried out with mattress stitches of thin silk or thread or chromicised catgut (the ordinary iodised variety being too rapidly absorbed to ensure lasting union). Cut vessels should be ligated and cut nerves sutured with fine catgut (see Chapter XII., p. 341).

Early movements and faradism are necessary to prevent adhesions in the tendon sheaths, but must be carried out cautiously, as there is danger of disruption at the suture line. In lacerated wounds whole muscles or groups of muscles may be avulsed, in which case the resulting wound must be cleansed and trimmed and the limb splinted so as to reduce subsequent deformity and disability to a minimum. It must be remembered that in cases where the limb is much disorganised or likely to be useless immediate amputation is often advisable. Where a portion of a limb is torn off by a machinery or other accident, the tendons in the part are often avulsed from their muscular attachment, and hang as long strands from the dismembered fragment (Fig. 191); this is seen most frequently in the case of the fingers, where the deep, and more rarely the superficial, flexor tendons may be avulsed with the digit in severe wrenching accidents.

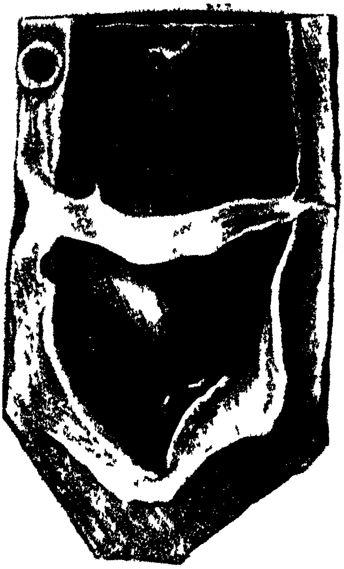


FIG. 197. Rupture of the rectus abdominis, the result of tetanic spasm.

The prognosis is much better after injuries of the extensor tendons of the fingers than those of the flexor tendons, as the sheaths are less complicated and adhesions less likely to occur.

Subcutaneous ruptures of muscles, tendons and fasciæ may result from a sharp blow or wrench, and are most excellently illustrated by rupture of the quadriceps extensor cruris and the tendo Achillis. Rupture of fascia occurs more or less extensively in any sprain, and is dealt with on p. 440; if repair is faulty, a muscle hernia (p. 385) or dislocating tendon (p. 385) may result.

A muscle most frequently ruptures at the musculotendinous junction, but occasionally may rupture in the muscle belly itself, either as the result of sudden great exertion (as is seen in the quadriceps), from tetanus (usually in the rectus abdominis), or as the result of local disease in the muscle, usually gummatous. On examination a gap can be felt in the muscle; this is usually occupied by a fluctuant swelling, due to effused blood, and can be felt to widen when an attempt is made actively to contract the affected muscle, the belly of which can be felt and seen as a rounded hardening mass, deep to the subcutaneous tissue.

Treatment consists in open operation as soon as possible, with removal of effused blood and clot, and accurate apposition of the cut surfaces by means of strong catgut or kangaroo tendon. Passive movements and gentle faradism should be resorted to in a few days and active movements quietly commenced in about a week. If for any reason operation is contra-indicated, the affected muscle should be kept relaxed by splinting the limb in a suitable position, when healing by granulation will occur. This is slow process, requiring from three to six weeks' rest; fibrosis occurs and the results are never satisfactory, as the ends tend to get adherent to adjacent structures.

Tendons also may rupture subcutaneously, the commonest situations being the tendo Achillis, about 2 inches above the heel, and the plantaris tendon. The patient experiences a sharp pain and sensation of snapping in the affected area, and often falls to the ground. On examination a gap can be felt, which widens when the muscle contracts, and the part below the line of breakage does not move in response to muscle action. The affected muscle can be felt to harden up. The gap, as in the case of muscle rupture, becomes filled with blood, which, if left, clots, organises, granulates and leads to fibrous repair of the injury.

The *treatment* is to cut down on the gap and suture the tendon with silk or chromicised catgut, after-treatment being given as for ruptured muscles, though, as repair is more rapid and very strong, so much caution in movements need not be observed after the first ten days.

Rupture of individual muscles and tendons is most commonly seen in—

(1) The **quadriceps extensor cruris**, which may be torn across partly or completely, usually just above the patella, by a sudden wrench, such as attempting to recover the balance from a slip on the stairs. Sudden acute pain and a sensation of snapping are accompanied by inability fully to extend the knee, which is held in a semiflexed position. Occasionally rupture of the *ligamentum patellæ* may result from a similar accident, as also *fracture of the patella*, which is the commonest result, and from which these other lesions can be distinguished by feeling the patella to be intact.

The *treatment* consists in open operation and suture with an autogenous fascial graft or strong catgut, the knee being slightly flexed and the limb placed in a plaster of Paris gutter. Massage and faradism should be started at once, and passive and active movements permitted in fourteen days; the limb may be walked on in three weeks.

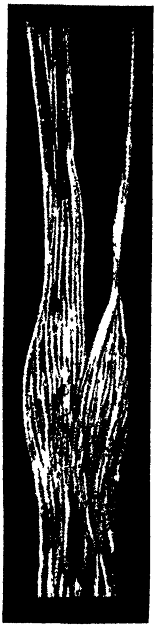


FIG. 198. Fibrosis at the site of an old rupture of the tendo Achillis.

(2) The **tendo Achillis** ruptures sometimes from very trivial injuries, as a sudden jar when running, and the trouble may be bilateral. There is inability adequately to plantar-flex the foot, and the gap can be felt in the tendon, usually about 1½ inches above the heel.

Open operation, with suture of the torn ends, should be resorted to at once, the method of treatment by flexion of the knee and strapping being tedious and unsatisfactory in results compared with operation.

(3) The **plantaris** usually ruptures as the result of sudden exertion while playing tennis (lawn tennis leg). There is stiffness in the calf, and attempts at plantar flexion cause cramp-like pain in the outer side of the leg.

Treatment consists in gentle use combined with massage and the faradic bath, which gives great comfort.

(4) The **adductor longus** may be torn from its attachment to the pubis in riding, or the **adductor magnus** from the femur. In both cases there is pain and stiffness with subsequent bruising.

Treatment consists in massage and gentle use, unless myositis ossificans traumatica occurs, which it is rather prone to do, forming a "*rider's bone*" either in the upper end of the long or the lower end of the great adductor, when complete rest is indicated.

(5) The **biceps brachii.** Usually the long head or muscle belly ruptures, but occasionally the lower attachment may give way; there is usually a sensation of tearing, and the muscle can be seen and felt as a soft mass rounding and hardening on attempted movement.

Treatment consists in suture with early massage and movements. An alternative proceeding is to pass the severed tendon through the short head of the muscle and stitch it to the coracoid process if it is long enough.

(6) The **erector spinæ** is liable to partial rupture, especially in the dorsilumbar region, as the results of straining to lift heavy weights or in wrestling. There is pain on movement, and the condition is frequently confused with both lumbago and osteoarthritis of the spine, which, of course, it may aggravate. Some authorities maintain that, as a result of the rupture of muscles, fibres and ligaments, slight displacements of the intervertebral and sacroiliac joints may occur (*sacroiliac strain*), a condition necessitating manipulations and electric treatment for its reduction, but in the vast majority of cases no such bony displacement can be shown by X-ray films, and the cases clear up well on massage.

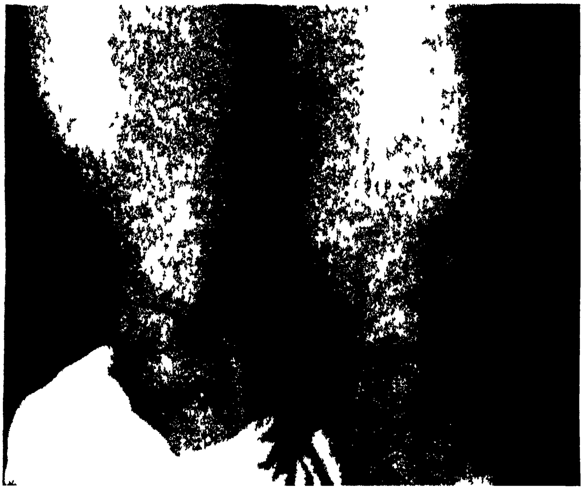


FIG. 199. Bilateral rupture of the quadriceps extensor cruris.

(7) **Rupture of the extensor tendons of the fingers** near their insertion into the distal phalanges may occur as the result of a blow on the end of the finger with a cricket ball, or in boxing. The finger becomes partly flexed, the region of the joint swollen and tender, and the finger cannot be extended. Unless the condition is promptly recognised and treated, this disability persists as a "**mallet finger,**" and may cause great inconvenience (see p. 482).

Treatment consists in flexing the fingers into the palm, when it will be found that the terminal phalanges are loose, owing to tension on the extensor tendon higher up and the long flexors being out of action. The terminal phalanx is then hyperextended and strapped to the palm in that position, and left thus for a week or ten days, by which time union is secure. Open operation does not give satisfactory results, as the tendon is torn off so close to the periosteum that there is no possibility of securing it to its attachment by stitches (Fig. 239).

A **Hernia of Muscle** may occur in the thigh or arm, but is seen only rarely, and results from rupture of the overlying fascia permitting the muscle, on contracting, to bulge through the resulting gap. If it occurs in the region of the groin and is small in size, care must be taken that the condition is not misdiagnosed as a femoral hernia or saphenous varix. Unless the condition is large or unsightly and causing inconvenience, no treatment is called for. The gap in the fascia, when necessary, can be exposed and closed, either by means of fascial grafts and sutures or by kangaroo tendon.

Slipping Tendons. Dislocation of a tendon from a bony groove in which it normally works may follow rupture of the fibrous sheath which usually holds it in place, and is most often seen in the case of the peroneus longus tendon after a sprained ankle, though other tendons may be affected. The tendon can be felt to slip from the groove when the part is moved; there is an accompanying sense of weakness, and maybe a snapping sensation, which is sometimes audible, as in "snapping hip," probably due to the gluteal insertion into the iliotibial band catching over the great trochanter. The long head of the biceps brachii is also dislocated at times (see p. 459).

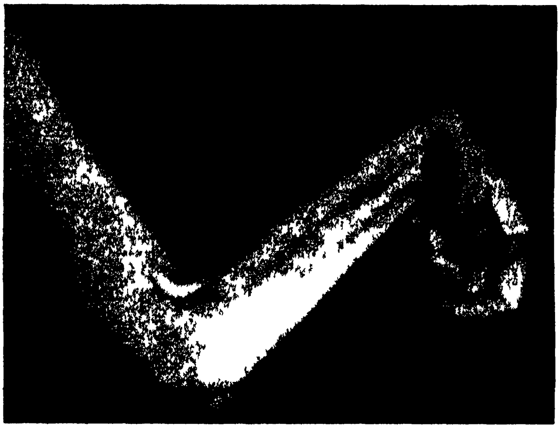


FIG. 200. Volkmann's ischæmic contracture.
Note pronation and flexion of wrist and fingers.

Treatment consists in replacing the tendon in its groove by manipulation, an easy matter, and retaining it there by strapping and if necessary splintage for two or three weeks, when if the condition has been of recent origin healing will have occurred and a satisfactory result may be anticipated. In old-standing cases, however, operation is indicated, and the tendon's fibrous sheath is reconstructed by means of periosteal flaps or fascial grafts.

Operations may be necessary to divide or lengthen shortened muscles and tendons (tenotomy and tenoplasty), or to implant a normal muscle and tendon into the tendon of a paralysed muscle in infantile paralysis (tendon grafting), and are dealt with in Chapter XXI.; there are described the various deformities which result if injured or paralysed muscles and fasciæ are not promptly treated and secured in such a manner as to prevent over-action of their opponents and the results of contracture consequent upon cicatrisation.

Volkmann's ischæmic contracture, resulting from the cutting off of the blood supply to damaged muscles, is seen occasionally as the result of splint pressure, usually in the flexors of the forearm and thigh, and is described fully in Chapter XIV., p. 410. Injuries to fasciæ and ligaments result in sprains and strains (Chapter XV., p. 440).

DISEASES OF MUSCLES, TENDONS AND FASCIÆ

Congenital absence or **deformity** of a portion or the whole of a muscle is occasionally seen, as in absence of the lower portion of the greater pectoral; or, again, muscle may be replaced from birth by bone and fibrous tissue, as occurs in the rhomboids and levator anguli scapulæ in "Sprengel's shoulder" (see p. 714).

Hypertrophy of muscle will occur as a physiological process from increased use, the muscle cells being increased both in size and number, and the entire muscle in bulk; the increase in size usually affects all the muscles of a group or limb, as is commonly seen in the greater muscular development of the right upper extremity in a right-handed worker, but may affect only one muscle, as in the case of the flexor brevis pollicis in surgeons from grasping knife and forceps; in such cases the swelling may be mistaken for a tumour of the affected muscle.

Atrophy of muscle may occur simply as the result of disuse, in the case of a paralysed limb or one put out of action by splinting, but so long as the nerve supply remains intact, *i.e.*, the lower motor neurone is not involved, there is no structural alteration, the muscle cells merely diminishing in size, with in late cases an increase in the intercellular fibrous tissue.

The muscles around a diseased and injured joint or diseased bone very early show trophic changes, due partly to neuropathic disturbance and partly to lack of use. The earliest change, noticed within a few days of the onset of trouble, is a loss of tone in the muscle, which is soft, flabby, and does not contract and harden on handling; in about ten days wasting can be appreciated, both by the eye and the tape measure. It is well to note that, although atonic and wasted, such muscles are usually in a state of tonic contracture or spasm

Electrical Reactions of Muscle. It is a well-known fact that normal muscle reacts briskly to a faradic current. A galvanic current also produces a contraction, there being a brisker response at the break than the make, while the contraction around the kathode (negative pole) is greater than that at the anode (positive pole); this is expressed by electro-therapeutists as K.C.C.>A.C.C.

In muscles to which the nerve supply has been cut off, either by injury or disease, a different state of the electrical reactions exists. There is no response to stimulation by the faradic current, and to the galvanic the response is weak and torpid, but persists as long as any muscle cells exist. It is, however, modified, the making of the current producing a greater effect than its breaking, and the contracture at the anode being brisker than at the kathode (A.C.C.>K.C.C.). These phenomena constitute the **reaction of degeneration** (R.D.), and are a sure sign that the nerve supply to a muscle is completely destroyed, faradic response being gradually re-established as the nerve supply regenerates. It follows, therefore, that if no faradic response is obtained in the muscles after a nerve injury, probably operation will be necessary to suture the nerve, and certainly only galvanic electricity will be of any value in maintaining the muscle tone until such time as experiment shows the muscle is again reacting to faradism (a sure sign of nerve regeneration), when the faradic current should be substituted for the galvanic (Chapter XII., p. 332). These reactions also serve to differentiate between simple muscle atrophy where a faradic response is obtained and a paralytic atrophy where R.D. is present. In the former case faradism is indicated as treatment, whereas in the latter it is useless.

Myositis. Inflammatory reaction occurs in muscle as the result of any injury, the usual result under the most favourable conditions being a fibrosis, complete muscle regeneration seldom, if ever, occurring.

(*a*) **Purulent myositis** may occur from direct infection with pyogenic micro-organisms following injury, or from blood-stream infection; in the former case the whole muscle may be converted into a spongy purulent mass, whereas in blood infections, such as occur sometimes in typhoid and chronic pyæmia, a localised abscess usually results.

The affected muscle is enlarged, tender and painful, and both active and passive movements are resisted, though the latter are less resented.

Treatment consists in free incisions and drainage, combined with fixation of the limb in such a position as to counteract as far as possible subsequent contracture.

(*b*) **Gonorrhœal fasciitis** (*q.v.*) not infrequently involves the muscles, but usually is an infection along the cellular planes. It is very painful, and subsequent contractures cause great disability (Chapter VI., p. 85).

Treatment in the acute stages consists of rest and fixation, which can be best carried out by splinting in plaster of Paris.

(*c*) **Tuberculous myositis** sometimes occurs, usually in the form of a definite nodule in the muscle as the result of extension from a neighbouring joint; caseation usually takes place, and a sinus may follow the curetting of the resulting abscesses.

(*d*) **Syphilitic myositis** may occur in the secondary stage, and is manifested by pain and some tenderness in the affected areas. In the tertiary stage (1) localised gummata may occur, and break down, forming a typical deep gummatous ulcer with a wash-leather slough (Chapter VI., p. 121); but (2) a more uncommon and interesting variety of this infection is seen in a diffuse gummatous infiltration which invades all the muscles of a group, which appear as a thickened and hardened mass, with no pain. Later fibrosis and consequent limitation of movement occur. This condition is liable to be mistaken for a sarcoma of muscle, from which, however, it can be diagnosed by a positive Wassermann reaction, and from the fact that it invades indiscriminately and early all the muscles in the area, whereas a sarcoma will spread up and down an individual muscle before invading its neighbours (Fig. 45).

(*e*) **Rheumatic myositis,** so called, is probably in reality a neurofibrositis due to a variety of causes. The affected muscle or muscles are somewhat tender, and considerable pain is experienced on active and even on passive movement. The best known examples of the condition are lumbago, stiff neck, and the painful shoulder or chest which may result from long keeping a cramped position, as in sleep.

Treatment, especially in lumbago, is unsatisfactory, the condition tending to relapse, but counter-irritation by blisters or iodine may be of benefit, and massage and hot-air baths are beneficial. In severe cases aspirin or even morphia may have to be given, but the latter drug should be administered with great caution, as there is danger of development of the " habit."

(*f*) **Parasitic myositis** may result from invasion by *Trichina spiralis* as the result of eating diseased meat, usually pork. The affected muscle, most often in the region of the shoulder girdle, is swollen and tender, and if incised is œdematous; it can be diagnosed from a purulent myositis only by recognition of the minute spiral worms in the fluid or portions of muscle removed. Echinococcus and other cysts are also met with (Chapter VI., p. 137).

(*g*) **Myositis ossificans** is usually of the traumatic type, and occurs in the muscles stripped from the bones as a result of injury (Chapter XIV., p. 416), but occasionally a true myositis ossificans occurs, and then the whole muscular system gradually becomes ossified. The disease occurs only in males and first affects the back muscles, calcified plaques appearing in these, which later ossify, the changes subsequently slowly progressing at intervals, till the involvement of the respiratory muscles usually causes death from pulmonary complications in about ten years from the onset of the disease. The condition is probably a fibrositis ossificans as in the traumatic variety, for section of the affected muscles prior to ossification shows marked proliferation of the fibrous elements, with atrophy of muscle cells.

Tendons may become inflamed secondarily to infection in the muscle, or in the tendon sheath. In either case there is an effusion in the tendon sheath, and if pus forms the resulting adhesions cause serious disability (p. 230). Inasmuch as the tendon is a poorly vascularised tissue, sloughing is very liable to occur if the infection is severe and not very promptly dealt with, the resulting disability being very crippling, especially in the fingers and hand.

Fasciitis results from the infection of the fascial planes by micro-organisms or their toxins, and clinically two common varieties occur :—

(*a*) **Gonococcal fasciitis** results from infection from the blood stream in cases of gonococcal septicæmia, and may occur in any region of the body, though the spinal column (poker back), soles of the feet (diplococcal pes planus), and ligamentous structures around the smaller joints, such as the temporo-mandibular and carpal joints, are most frequently affected (see pp. 85 and 596).

Clinically the condition is characterised by a very sudden onset with acute pain, so that the patient generally will name the exact hour of its onset, and which may be unbearable for some hours and then tends to improve steadily up to a certain point. The affected area is tender to the touch, held rigid, and effusion can be detected in neighbouring joints, tendon sheaths and bursæ. Suppuration is rare in the fasciæ, but by no means uncommon in the synovial sacs. Where weight has to be supported by the inflamed and weakened fasciæ, these give way, as in the foot, when a painful and rigid flat foot results.

Microscopically the affected fascial planes are seen to be in a state of acute inflammation and densely packed with leucocytes and gonococci in the early stages of the disease ; later dense fibrosis occurs, with contraction and atrophy of muscle fibres among the fascial strands. Numerous diplococci can be seen amongst the fibrous tissue, which explains why after manipulation, which tears this tissue and releases the micro-organisms, the local condition relapses and " flares up," and even generalised septicæmia may occur. The effusion into the synovial sacs is usually sterile, but should gonococci be detected the prognosis is bad, as suppuration nearly always ensues (Chapter XIX., p. 596).

The *treatment* consists in complete rest, the affected area being fixed in the most advantageous position to secure a useful member should the periarticular fibrosis produce " false ankylosis " (p. 595) in neighbouring joints, as is unfortunately all too frequently the case. Massage to the affected area should be avoided strenuously, as it will much aggravate the local condition. Should suppuration occur it must be dealt with promptly by free incision and drainage; but care must be taken not to open joints or bursæ, which, as already pointed out, frequently contain a sterile effusion, through infected fascia, or suppuration with disastrous results is sure to follow. The best guide as to whether pus is present in the cavities is afforded by the pulse and temperature and throbbing nature of the pain if suppuration has occurred. Sulphanilamides should be given and vaccine treatment may be of value in these cases. The prognosis is always grave owing to the frequency of fibrous false ankylosis and consequent crippling disability, which may be very extensive.

(*b*) **Rheumatic fibrositis,** so called, includes a large number of conditions when the fascial planes and muscles show hyperæmic changes; sometimes micro-organisms may be present, but this is not usually the case. In many cases very tender fibrous nodules form in the fasciæ and muscles in this condition. An especially common spot to find these is in the trapezius muscle just above the angle of the scapula.

Stiff neck, lumbago, etc., all fall under this heading, but care must be taken in all cases to eliminate the possibility of a gonococcal infection before rheumatic fibrositis is diagnosed.

Stiff neck usually follows exposure to a draught, but may occur from long maintenance of the head in a cramped position; the muscles, notably the sterno-mastoid, of the affected side are held rigid, with the result that " wry neck " is present, and all attempts at either active or passive movement are resented and painful, thus showing the fascia to be affected (see Vol. II., Chapter X.).

Lumbago. The region of the loins is painful, stooping and straightening the back both being well-nigh impossible in the acute stages, and the patient adopting a semi-stooping position. The pain may be agonising. Careful examination reveals tender points, probably corresponding to nerve endings.

The deltoid, intercostals and calf muscles also may be affected.

Treatment consists in the administration of aspirin or salicylates and the local application of heat and friction, which can be coupled advantageously with massage. Needling and the application of counter-irritation in the form of mustard leaves and blisters may be useful in intractable cases. In all such cases care must be taken to eliminate reflex spasm due to enlarged glands, joint disease, etc., and in all intractable cases a urethral or vaginal smear should be examined for gonococci. In all cases a local or focal source of sepsis must be searched for and if possible removed. Sepsis in connection with the roots of the teeth is by far the commonest cause, and septic tonsils and bowel infections also must be remembered.

(*c*) **Purulent fasciitis,** due to infection with staphylococci or streptococci, either as the result of direct or blood-stream infection, is dealt with under Cellulitis (Chapter V., p. 71).

TUMOURS OF MUSCLES AND FASCIÆ

As with the exception of very rare rhabdomyomatous tumours the neoplasms of muscle arise, not in connection with the muscle cells, but from the fibrous fascial framework, it will be convenient to discuss the tumours of both tissues under the same heading.

As all muscles and fasciæ are mesoblastic in origin, it follows that primary tumours are of the connective tissue series (Chapter VIII.).

(*a*) *Simple primary tumours*, lipomata, fibromata, fibromyomata, chondromata and angiomata are all occasionally met with, and are treated by excision. Fibromata tend to malignancy, and the hard ovoid "recurrent fibroid of Paget," not infrequently seen in the abdominal muscles, is in all probability a fibrosarcoma of low malignancy (Chapter VIII., p. 197). Chondromata also tend to malignancy and may ossify or undergo hyaline degeneration, presenting a fluctuant cystic mass.

Fibromyomata occur commonly in connection with unstriped muscle and are frequently seen in the uterus (Vol. II., Chapter XXII.).

(*b*) *Primary malignant tumours* are sarcomatous, usually of the spindle-celled variety and mixed with a varying amount of fibrous tissue. It is characteristic of sarcoma starting in a muscle that the neoplasm tends to infiltrate the entire muscle, which appears clearly outlined and larger and harder than its neighbours, before penetrating the perimysium and invading the surrounding muscles; this serving to distinguish sarcoma in its early stages from gummatous infiltration (p. 219), where all the muscles of a group tend to be infiltrated early, and to form an ill-defined thickened mass in which the outline of individual muscles is obscured and cannot be detected.

Treatment consists in the early stage in excision of the affected muscle *in toto*, but later, when the sarcoma has invaded surrounding structures, amputation in the case of a limb will be necessary, care being taken to remove in their entirety all affected muscles. The diathermy knife can be employed in excising any single muscle.

Radium may with advantage be used in the form of 1 mg. needles planted 1 cm. apart, or deep X-ray treatment instituted.

(*c*) *Secondary deposits* may occur in the muscles and fasciæ in cases of carcinoma, hypernephroma, or sarcoma elsewhere in the body, either by direct invasion from the primary focus (*i.e.*, the pectoralis major in carcinoma mammæ), from invasion from infected underlying glands (in the sternomastoid from carcinomatous glands secondary to carcinoma linguæ), or as the result of emboli in the blood or lymph stream.

Radical treatment is in most cases useless, and the best that can be hoped for is to delay the disease by X-ray therapy or injections of collosal copper or lead (Blair Bell).

Cysts of hydatids or cysticercus cellulosæ may be met with occasionally in muscles, tendons, or fasciæ, and call for excision.

THE BURSÆ AND TENDON SHEATHS

Both the bursæ and tendon sheaths are essentially of the same structure as the synovial membranes of the joints, and, like them, secrete glairy synovia from their endothelial lining with the object of promoting easy movements without friction on surrounding structures. It follows, therefore, that all these three synovial sacs are liable to the same pathological changes and will present similar clinical features, though the actual signs may be somewhat modified according to the situation and associated structures of the synovial membrane; for this reason it is advisable to deal with bursæ and tendon sheaths separately, and customary to discuss the diseases of the synovial membranes of joints in conjunction with those of the adjacent bone.

INJURIES OF TENDON SHEATHS

Tendon sheaths may be laid open in punctured, incised or lacerated wounds, when the enclosed tendon is usually injured and needs suture. If the wound heals aseptically the sheath usually re-establishes itself, but occasionally troublesome adhesions result between the sheath and tendon, and this is particularly liable to occur in those cases where blood is effused into the tendon sheath or infection occurs. In such cases attempted movements of the affected tendon produce only a limited result, and the surrounding tissues can be seen to be dragged on ; there is a drawing sensation experienced in the affected part.

Treatment consists in gentle massage and movement, which may be combined with occasional manipulation under gas, but care must be taken that no violent local reaction is produced, or the adhesions will reform before any movements can be undertaken. If acute suppuration occurs in the tendon sheaths it must be dealt with promptly as described under Acute Suppurative Tenosynovitis (see below) ; the chances of obtaining a useful member are remote and the prognosis consequently serious.

Acute tenosynovitis not infrequently results from overuse of a certain muscle, as the extensor ossis metacarpi pollicis (abductor pollicis longus) in wringing out clothes.

The sheath of the tendon becomes distended with glairy fluid, and as this sheath surrounds not only the tendon, as can be anatomically demonstrated, but also extends some way up around the muscle belly, this can be felt to be enlarged and tender, and in severe cases to be encased in a fusiform fluctuating swelling. Movements of the affected muscle are painful and produce a characteristic fine crepitus easily detected on palpation while the muscle is in action.

Treatment consists in absolute rest for three or four days, the affected muscle being secured in a relaxed position by strapping or bandaging, which must, of course, also fix the joint. Salicylates by the mouth are often valuable. Thereafter massage may be employed and gentle use indulged in. The condition is usually cured in about ten days, but there is a distinct tendency to relapse, and if neglected **chronic crepitating tenosynovitis** may result.

This condition is somewhat intractable, and results in a weakened joint, with restricted movements due partly to adhesions and partly to wasting of the affected muscle. There is usually a small amount of effusion in the tendon sheath, which is thickened and creaks on attempted movement or manipulation.

The condition is not infrequently seen in the tendo Achillis just above the ankle as the result of wearing badly-fitting boots. Some authorities regard this chronic tenosynovitis as being of a mild infective nature, but the fluid is sterile in the vast majority of cases, and a definite traumatic history is obtainable.

Treatment consists in counter-irritation by Scott's dressing and a pressure bandage, or pigmentum iodi and strapping. In severe cases plaster of Paris splinting for ten days may be advisable. Thereafter faradism and massage are beneficial combined with gentle use, full use being permitted in three weeks. Relapse is not uncommon. In some cases, apparently rheumatic in origin, treatment by salicylates produces rapid improvement.

DISEASES OF TENDON SHEATHS

The powers of resistance of synovial membranes to acute infections are very poor, and the membrane being in addition well supplied with blood and lymph vessels, infection spreads rapidly and extends to other tissues, while general toxæmic symptoms are very marked.

Acute suppurative tenosynovitis is a most serious and crippling disease, and where, as in the case of the tendons around the wrist joint, the sheaths are extensive and communicate freely, very grave disability may result, or the limb have to be sacrificed in the event of septicæmia or severe general toxæmia ensuing.

The infection usually reaches the sheath by direct spread, as from a prick on the finger or a whitlow, but may result from a blood-borne organism, as in gonorrhœal tenosynovitis. *Clinically* the condition is usually secondary to a thecal or palmar whitlow, there being, therefore, a short history of a painful swelling of the finger or hand for a day or so preceding the graver and more extensive complication (Chapter IX., p. 233). The whole hand is puffy and very painful, there often being great œdema on the back of the hand, due to the dense palmar fascia preventing the swelling showing in the palm, wherefore it travels around the sides to the dorsum. The fingers are semi-flexed and waxy in appearance and any attempt at movement evokes agonising pain. If the infection has spread into the forearm, on the front of this is a brawny and œdematous swelling, above a fairly sharp constriction of tissue on the front of the wrist corresponding to the anterior annular ligament. There may be red streaks of lymphangitis in the arm and the axillary glands are enlarged and tender. In the later stages pus may point in the clefts between the fingers, when the skin becomes red and shiny, and anywhere in the front of the forearm, in both of which situations fluctuation can then be detected. In neglected cases gangrene of skin may occur and tendons frequently slough, with resulting disability. General symptoms are usually severe, there being high hectic temperature, vomiting, anorexia, a furred tongue and constipation; in some cases septicæmia or pyæmia may complicate the disease.

Treatment consists in immediate and free incisions. In so far as possible the palmar fascia should not be divided, but cuts made in the clefts along the thenar and hypothenar eminences (Fig. 128), care being taken to avoid digital vessels and nerves, and the pus evacuated from beneath the fascia by this route. In the forearm multiple small lateral incisions are preferable to one large one, and, if necessary, perforated rubber tubes may be passed between these through the infected muscle planes. Hot baths frequently given, or Dakin's irrigation, may be very valuable in extensive cases, as is also Bier's congestion, applied by means of a rubber bandage, once the pus has been evacuated; dry dressings may be applied between whiles and are preferable to fomentations, which render the skin sodden and liable to superficial infection. Vaccines may be useful, especially in those cases where general infection supervenes. Should dead and sloughing tendon be present in the wounds it must be cut away. The prognosis is always grave, especially if tendons have sloughed, for dense adhesions prevent free movement and cause great crippling, a more or less claw-like hand usually resulting. Massage, faradism, active and passive movements and manipulations under anæsthesia should, however, be patiently persisted with up to one or two years, and wonderful improvement may be obtained with these methods in apparently hopelessly crippled hands.

Gonococcal tenosynovitis is usually met with in the sheaths around the ankle and wrist, but may occur in the neighbourhood of any tendon, and very frequently goes on to suppuration, the typical bun-shaped diplococci being detected in the pus. The onset is usually very sudden and painful, the affected sheaths being swollen and tender and all movements resented; superjacent tissues are often œdematous. With the enforced rest, the condition generally ameliorates somewhat, but tends to become chronic, and as dense adhesions form in the tendon sheaths, great disability results from the restriction of movements. As already stated, the condition frequently goes on to suppuration, especially if the affected part is used in spite of the pain; redness and fluctuation then manifest themselves, but sloughing of the tendon is extremely rare.

A sterile effusion not infrequently occurs in neighbouring joints, and as the urethral discharge tends to disappear with the onset of complications, a diagnosis of acute rheumatism may be made in error (Chapter VI., p. 138).

Treatment consists in resting the part by fixation in plaster of Paris or strapping, the limb being fixed in the best position to ensure utility should fixation occur. Vaccines or serum may be useful in intractable cases. The urethral condition must receive attention.

Tuberculous tenosynovitis is a fairly common disease, and may occur either as an infection of the tendon sheath from the blood stream or by spreading from adjacent structures; it is in every way analogous to the infection of the synovial membranes of the joints (Chapter XIX., p. 599). The disease is usually of insidious onset and comparatively painless, the patient noticing a gradually increasing swelling with weakness of the affected part. The commonest situations are around the wrist and ankle, and there is always marked loss of tone and wasting of the muscles of the affected tendons. General symptoms include a hectic temperature, with its maximum about 7 p.m., asthenia, and not infrequently other foci of the disease, are present.

Clinically two varieties of the disease are met with, and it is desirable to discuss these separately.

(*a*) The type with effusion is perhaps the commoner, and shows a fairly considerable serous effusion into the sheath, the endothelium of which granulates and becomes slightly thickened by deposition of fibrin, which the movements of the tendon in the sheath round off and separate, so that the whole space may become packed with a mass of gelatinous flattened fibrous bodies called "*melon seed bodies*" from their close resemblance thereto. These can often be palpated in the sheath as a series of nodules, and in addition give a fine crepitant sensation to the hand. Fluctuation can be detected over the affected area and the swelling is usually visible as a longitudinal fusiform subcutaneous enlargement. The condition is aggravated by use of the affected muscles, but usually remains restricted to the sheath; the superjacent structures seldom become infected, involvement and ulceration of the skin being a rare complication in this variety of the disease.

The infection not infrequently involves the common flexor tendon sheaths of the palm and forearm, when a condition known as **compound palmar ganglion** is seen, in which a fluctuant swelling exists in the palm and front of the forearm with a band-like constriction across the front of the wrist, due to the anterior annular ligament, which divides it into two apparently separate swellings; fluctuation can be obtained from one to the other of these two swellings.

Treatment consists in resting the part in a suitable position, dorsiflexion in the case of the wrist and ankle, by fixation in plaster of Paris splints for at least three months. The condition usually yields to such treatment, but should it not do so, the sheath should be opened and the fluid and melon seed bodies removed, the wall curetted and the wound closed; the limb is then refixed in a plaster splint. Treatment by injection of emulsions of iodoform or B.I.P. is not more satisfactory in its results than the foregoing.

(*b*) The second variety is that in which the whole endothelial lining becomes much thickened and converted into a mass of tuberculous granulation tissue, which is very œdematous and tends to caseate and break down, besides invading the muscles, tendons, and superjacent skin and subcutaneous tissue, where ulceration frequently results. The prognosis is, therefore, not so good as when effusion occurs. The tendon sheath presents as a fusiform thickened mass, often adherent to surrounding tissues, which may be œdematous or discoloured and ulcerating; the muscle may be thickened and nodular, and no fluctuation can be detected.

The condition may be mistaken for a gummatous tenosynovitis (*q.v.*) or for a simple tumour, the latter being more likely when a considerable sheath is affected, as in compound palmar ganglion.

Treatment. Conservative treatment by rest and fixation should be tried, but is not by any means always successful, when complete excision of the infected sheath should be attempted with curetting away of tuberculous foci in the muscle or tendon. X-rays or radium may be useful in the healing of sinuses. The prognosis is not good, as adhesions are likely to form and result in impaired movement, and sinuses not infrequently form and persist.

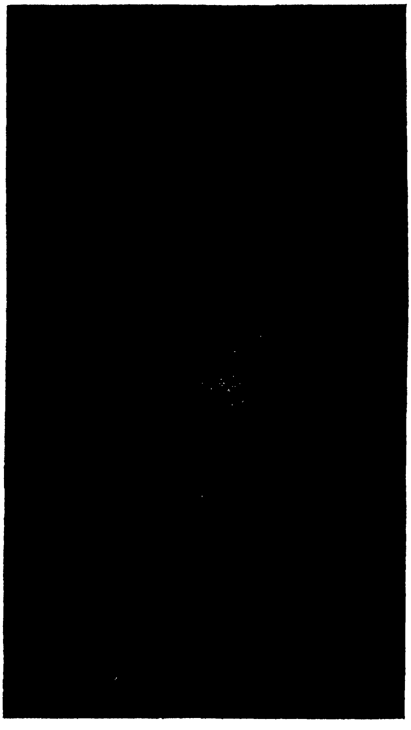


FIG. 201. Gout, showing tophi on the hand and deposit in the olecranon bursa.

Syphilitic tenosynovitis may occur as a transitory event in the secondary stage, when a painful effusion appears for a few hours or days. In the tertiary stage localised or diffuse gummatous infiltration may occur, and is usually symmetrical and always painless; ulceration frequently results from involvement of superjacent skin and subcutaneous tissue.

The condition is liable to be mistaken for the diffuse granulating form of tuberculous tenosynovitis, but the symmetry of the lesions and the clinical features of the ulcers should lead to the taking of blood for a Wassermann reaction.

Gouty tenosynovitis. Deposits of sodium biurate not uncommonly occur in the endothelial lining of the tendon sheaths in gouty individuals, and may take the form either of thin plaques or localised nodules (tophi), which, like the subcutaneous tophi, may ulcerate through the skin, leading to the formation of gouty ulcers. Excision of tophi may be called for in some cases.

CYSTS AND TUMOURS OF TENDON SHEATHS

These are of rare occurrence, and if primary are of the connective tissue type. Of the simple neoplasms, *lipoma* (sub-synovial) and *hæmangioma* are most often met with, and present as a diffuse, soft, elongated swelling which is usually diagnosed as tuberculous tenosynovitis, the diagnosis being established at operation when conservative treatment has naturally failed to cure the condition. Fibroma and myxoma are also occasionally met with.

Myeloma arising in connection with the sheaths in the neighbourhood of the fingers and wrist is not uncommon, and presents as a soft rounded localised swelling which is usually diagnosed as a ganglion, this on removal proves to be a soft orange-yellow tumour, which on section shows numerous giant cells in a connective tissue matrix The giant cells are less numerous than in the myelomata of bone and clear "foaming" cells are also present.

FIG 202 Lipoma arising in the tendon sheaths of the thumb

FIG 203 Ganglion of wrist

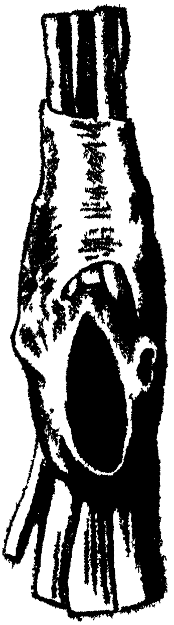


FIG. 204 Ganglion of wrist, laid open

Recurrence after removal is rare and metastases unknown, the prognosis being therefore good.

Sarcoma is a malignant neoplasm met with very rarely as a primary tumour of a tendon sheath, when it is usually very malignant and disseminates rapidly; more frequently the sheath is secondarily invaded by a sarcoma originating in the periosteum or muscles

Treatment consists in amputation or application of radium if no secondaries can be detected.

Cysts of Tendon Sheaths. A **ganglion** is a localised cystic swelling which may arise (*a*) in connection with a herniated portion of a tendon sheath which has become partly or entirely shut off and detached, (*b*) in a displaced islet of synovial tissue, or (*c*) as a myxomatous degeneration of the fibrous tissue of a tendon sheath. These swellings are usually met with around the wrist or ankle and present as a tense rounded or oval cystic structure, attached to the deeper tissues, but not to the skin. The tumour, if large, may be bilocular, and is always translucent. Attachment to the adjacent tendon sheaths can seldom be demonstrated. Very small tense ganglia are sometimes seen in connection with the flexor sheaths of the finger, usually near where the finger meets the palm. They are so small and hard that they may resemble exostoses.

Treatment consists in excision, a by no means easy operation, as the cyst wall is thin and usually ruptures, allowing its clear jelly-like contents to escape, but complete removal of the wall is essential for cure. The ganglion usually can be ruptured subcutaneously by manipulation, and this sometimes occurs following a blow, but recurrence is common, as the rent in the cyst wall heals and the endothelium being intact the ganglion soon reappears. Occasionally, however, cure takes place, and thus rarely spontaneous cure may follow an accidental blow.

The diagnosis is usually easy, but there are two conditions with which a ganglion may be confused: (1) a growth of a tendon sheath, which is not translucent; (2) a Morant Baker's cyst (Chapter XIX., p. 611), which, being nipped off from the synovial membrane of an adjacent osteo-arthritic joint, may be met with in elderly people in the cellular tissue around a creaking and lipped joint.

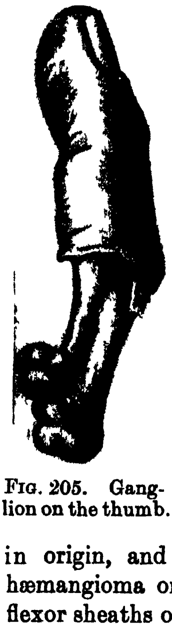


FIG. 205. Ganglion on the thumb.

Compound palmar ganglion has been fully described under tuberculous tenosynovitis, to which it is due in the vast majority of cases; rarely, however, it may be gummatous in origin, and is closely simulated by both a sub-synovial lipoma and hæmangioma on those rare occasions in which these tumours occur in the flexor sheaths of the palm and forearm.

THE BURSÆ

Bursæ occur at any points in the body at which it is desirable to avoid friction, either between two muscles or tendons (semi-membranosus bursa), or between bony prominences and the skin (olecranon and prepatellar bursæ), in many such situations bursæ are normally present. Under certain conditions, usually occupational, where pressure or friction develops between outside bodies and the deeper tissues through the skin, new bursal sacs tend to develop; these are usually in the subcutaneous tissues, and are then known as **adventitious bursæ**, a good illustration being the bursa developed on the root of the neck, over the trapezius and acromion process in flower sellers who carry their baskets on their shoulders, or in that seen over the prominent tarsal bones in the different varieties of talipes or hallux valgus. These bursal sacs, whether normally present or adventitiously developed, consist of a closed space in the connective tissue, lined with endothelium and secreting synovia, which, if in excess, will distend the lumen of the sac, so that this is palpably enlarged.

Injuries to bursæ are not infrequent, as these are situated in the subcutaneous tissues, over prominent points, the prepatellar and olecranon bursæ being particularly exposed to trauma.

Incised and punctured wounds may involve a bursa, and this fact is indicated by the escape of the clear, sticky, honey-like synovia from the wound. The continued escape of this may delay healing, in which case the bursa needs to be excised. *Contusions* may result in a hæmorrhagic effusion into the bursal sac, which is distended, painful and thickened, there being often considerable bruising of the surrounding skin and subcutaneous tissues. This is very prone to occur after slight trauma in certain blood diseases, as hæmophilia and scurvy, where of course no attempt must be made to aspirate or otherwise remove the clot from the bursa.

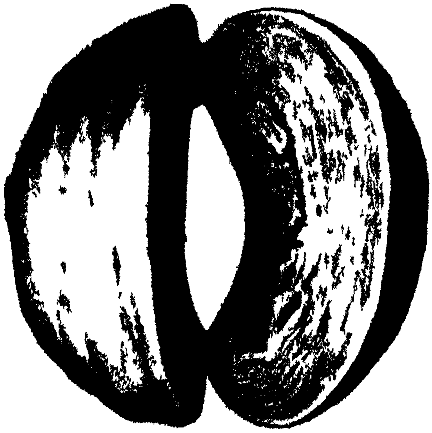


FIG. 206. Chronic prepatellar bursitis, with almost complete obliteration of the bursal space.

Treatment in such conditions consists in rest to the part, with aspiration of the effusion if large, and subsequent gentle massage.

There are two common complications secondary to traumatic effusion into a bursa.

(1) Repeated slight trauma, as is liable to occur in the prepatellar bursa, leads to a condition of chronic effusion into the sac of blood and synovia; this organises, and the fibrin becomes deposited on the endothelial wall, where fibrosis ultimately occurs, which, besides thickening the wall, prevents proper absorption of the effusion. The whole bursa thus becomes much enlarged and the walls enormously thickened by the deposit of layers of fibrin and fibrous tissue, so that the sac becomes firstly greatly distended and ultimately almost obliterated, though a small central cavity always remains. This form is known in the early stages when effusion is present as **chronic traumatic bursitis** or **hydrops bursæ,** and in the later stages when the sac is obliterated by the concentric layers of fibrin as **chronic fibroid bursitis,** both conditions being most frequently seen in the prepatellar bursa, but also met with elsewhere. The only efficient treatment consists in excision of the affected bursal sac.

(2) Infection of the effusion into the space is a second common complication, **acute suppurative bursitis** resulting.

Infections of Bursæ. Acute suppurative bursitis is usually of staphylococcal origin and follows on infection of a bursal effusion or a direct wound of the sac, the synovia and blood forming an excellent pabulum with but little resistance to the growth of the micro-organisms. Bursæ also become infected *via the lymphatics from septic lesions in their neighbourhood. The pus, at first confined to the bursa, soon breaks through into the surrounding tissue and* a very extensive burrowing abscess may result, or a spreading cellulitis, the affected area showing all the signs of acute inflammation with localised pus formation.

Treatment consists in incision and drainage, but excision of the sac may be required in the later stages if the wound does not heal and synovia and pus continue to be excreted.

Gonococcal bursitis occurs during the course of a gonorrhœal septicæmia, and is associated usually with a tenosynovitis and arthritis, which it closely resembles both in suddenness of onset, pain and partial improvement. Suppuration is rare, and the condition yields to rest and vaccine therapy.

Tuberculous bursitis, like tenosynovitis (see p. 393), which it much resembles, is of two types, (1) that with effusion (hydrops bursæ), and (2) that with thickening and granulation of the synovial membrane. The condition may be primary, when it occurs most frequently in the sub-deltoid or gluteal bursæ, or in the case of those bursæ which communicate with a joint, such as the psoas bursa with the hip, and the popliteus, semi-membranosus and sub-crureus with the knee, the infection may occur by direct extension from the articular cavity. In either case the bursa gradually increases in size and its walls can be felt to be thickened and often nodular; effusion is usually present, and can be detected by obtaining fluctuation. There are no local signs of inflammation and the condition forms one type of "*white swelling,*" an old name for tuberculous disease of joints and bone (Chapter XIX., p. 600). Peribursal extensions, with formation of tuberculous abscesses and sinuses and subsequent secondary infection, are frequently seen in untreated cases. The only satisfactory treatment in the case of bursæ not communicating with joints is total extirpation, counter-irritation, pressure, incision and curetting all being much inferior in their results. Where the bursa is infected secondarily to joint disease, the treatment of this latter condition (Chapter XIX., p. 602) will result in amelioration and cure of the bursal infection.

Syphilitic bursitis is nearly always symmetrical in distribution, as is the case in syphilitic infections of bilateral organs (Chapter VI., p. 117), the infection in the second organ starting from three to six weeks later than in the first.

In the secondary stage of the disease sudden painless effusions are apt to occur, which disappear in the course of about ten days, but tend to relapse; similar conditions are met with in the joints and tendon sheaths, and are classed as *recurrent hydrops.*

In the tertiary stage localised gummata may form with subsequent ulceration, but more frequently a diffuse gummatous thickening occurs in and around the synovial lining of the bursa, which becomes much thickened and enlarged, some effusion being present, and the corresponding bursa on the opposite side becoming subsequently affected. The condition closely resembles chronic traumatic fibroid bursitis, from which it can only be diagnosed with difficulty; the presence of symmetrical lesions of the prepatellar bursæ should always lead to a Wassermann reaction being performed before excision is attempted, as such an operation in an untreated syphilitic is followed by gummatous ulceration in the wound and breaking down of the scar.

Treatment consists in establishing the diagnosis and treating the syphilis, but in the case of chronically thickened gummatous bursæ subsequent excision is usually necessary.

Gouty bursitis. Urate of soda is frequently deposited in large amounts in the bursæ of gouty subjects, so that the sac may become obliterated and distended by a hard chalky mass, the skin over which may give way, a "gouty" ulcer resulting (Chapter VI., p. 136).

Effusions also occur in the bursæ in *acute rheumatism* and in certain *zymotic fevers* (notably scarlet fever), when the neighbouring joints also will be affected.

The bursæ around and communicating with joints in which chronic changes of an osteo- or rheumatoid arthritic nature (Chapter XIX., p. 607) are occurring, frequently become distended with fluid, partly as a result of secretion from degenerating and irritated synovial lining, and partly by passive effusion from the joint; later they may become detached and form one variety of Morant Baker's cyst (Chapter XIX., p. 611).

The treatment consists in aspiration or excision.

The old term "hydrops bursæ," which was used to denote any chronic effusion into a bursal sac, will from the foregoing be seen to be applicable to a variety of conditions, namely:—

(1) Chronic traumatic bursitis; (2) tuberculous bursitis; (3) secondary syphilitic bursitis; (4) osteo-arthritic bursitis.

Tumours of bursæ are excessively rare, but connective tissue neoplasms similar to those affecting tendon sheaths may be met with.

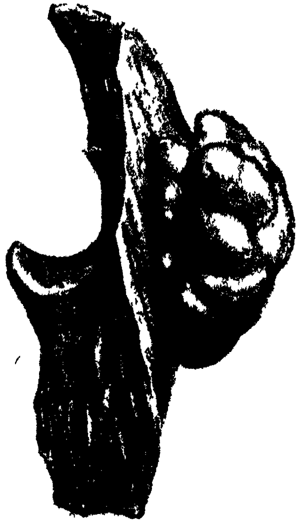


FIG. 207. Gouty deposits in the olecranon bursa.

AFFECTIONS OF INDIVIDUAL BURSÆ

The **prepatellar bursa**, situated over the lower part of the patella and upper part of the ligament, may consist of two or three sacs, but never communicates with the knee joint. It is from its situation very liable to both trauma and consequent infection; chronic traumatic bursitis (*housemaid's knee*) and acute suppuration are both frequently met with, especially in charwomen. The latter may resemble very closely an acute arthritis of the knee as there may be a secondary effusion into the knee joint. Tertiary syphilitic infection is not uncommon and needs careful diagnosis from housemaid's knee (p. 399).

The **subpatellar bursa** between the ligamentum patellæ and the anterior surface of the tibial tubercle and head is situated in the base of the ligamentum mucosum and does not communicate with the knee joint, but owing to its situation it may be infected secondarily if the joint is diseased, and *vice versâ*. When distended with fluid this bursa can be detected bulging on either side of the ligament in its lower part, and is more obvious when the knee is extended. Primary infection is rare, but needs prompt treatment because of the close proximity of the bursa to the joint cavity. A chronic infection sometimes occurs in this bursa in those who kneel frequently (*Clergyman's knee*).

The **subcrureal bursa** communicates so freely with the suprapatellar pouch of the knee joint, that for all practical purposes it may be considered as part of the synovial cavity of that joint.

Numerous bursæ exist in the popliteal space lying between the muscles; of these two are important, as normally communicating with the knee joint.

(1) The **semi-membranosus bursa,** lying between the tendon of the semi-membranosus and the inner head of the gastrocnemius, opens into the joint by a slit-like orifice which may become obliterated in chronic inflammation and thus shut the bursa off from the knee joint. Clinically the bursa when enlarged presents as an ovoid egg-like swelling on the inner aspect of the popliteal space, obvious and tense when the leg is extended, but less so when the limb is flexed, as it partly empties into the joint and partly disappears beneath the gastrocnemius. Care must be taken to ascertain that no disease is present in the knee joint. Chronic enlargement is usually seen in young girls.

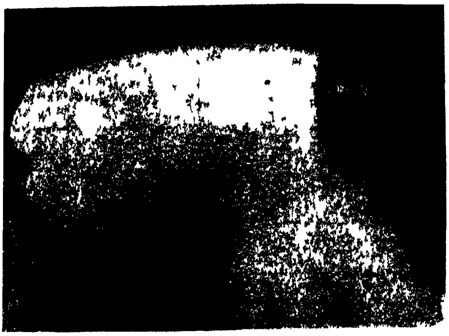


FIG. 208. Chronic prepatellar bursitis. "Housemaid's knee."

Treatment consists in aspiration when it communicates with the joint, or excision if causing much inconvenience and shut off from a healthy joint.

(2) The **popliteus bursa** is really a tendon sheath and constitutes when inflamed an elongated swelling on the outer side of the back of the external femoral condyle deep to the biceps tendon and iliotibial band. The condition may be confused with cystic degeneration in the external meniscus, a condition which it closely resembles.

Of the other bursæ in the neighbourhood of the knee, none of which ever communicate with the joint, those most commonly enlarged are: (3) The bursæ around the sartorius, gracilis and semi-tendinosus insertions into the inner side of the head of the tibia, and usually called **sub-sartorial bursæ.**

(4) The **bicipital bursa,** situated just above the head of the fibula, between the long external lateral ligament of the knee joint and the biceps tendon, where this latter is split by the former.

Enlargement of this bursa is liable to be confused with cystic degeneration of the external semilunar cartilage (see p. 512).

The bursa beneath the tendo Achillis, between this and the upper part of the os calcis, is enlarged as the result of friction from ill-fitting shoes.

The **psoas bursa,** situated between that muscle and the front of the hip, frequently communicates with the joint, in which case it becomes distended secondarily to hip disease, and forms a prominence in the groin, with a tendency to psoas spasm and flexion of the joint (Chapter XX., p. 623).

If the bursa does not communicate with the joint it may be distended and simulate an effusion into the joint, secondarily to disease of the psoas muscle, as occurs in psoas abscess following spinal caries (Chapter III., Vol. II.), or more rarely to appendicitis (Chapter XVII., Vol. II.).

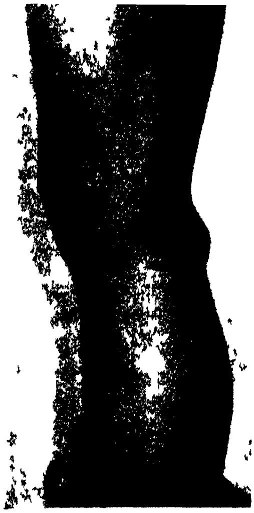


FIG. 209. Semi-membranosus bursitis.

The bursæ in the neighbourhood of the great trochanter of the femur between the gluteal tendons may become inflamed and distended as the result of trauma or from caries of the trochanter.

The **ischial bursa** over the tuber ischii is not infrequently the site of a chronic traumatic effusion, and then constitutes a prominent and painful swelling, known as "*weaver's bottom*," which can be cured only by excision.

The **olecranon bursa** over the olecranon process of the ulna is almost as frequently seen chronically inflamed (*student's or miner's elbow*), or acutely infected, as is the prepatellar bursa, and, like it, never communicates with the adjacent joint.

The **subdeltoid bursa** (sub-acromial) situated deep to the deltoid, between that muscle and the great tuberosity, seldom if ever communicates with the shoulder joint; when inflamed it forms a localised fluctuating swelling deep to the muscle, and active abduction is restricted, but passive movement is full and painless, this usually sufficing to distinguish the condition from infection of the shoulder joint. Complete removal of the bursa by dissection is by no means easy, and curettage with subsequent fixation of the limb in the abducted position is probably the best treatment to adopt in tuberculous infections of this bursa.

FIG. 210. Olecranon bursitis.

Adventitious bursæ, all of which may be regarded as the result of chronic trauma, are met with in a variety of situations and often are noticed only when they become infected or inflamed. The most common are:—

(*a*) On the scalp in porters who carry loads on the head.

(*b*) Over the upper dorsal vertebræ in porters carrying loads on the back and known in Covent Garden as a "hummy."

(*c*) On the external malleoli of tailors and native races who use the squatting position, especially if cross-legged.

(*d*) On the shoulders of persons who carry burdens thereon.

(*e*) Over the bony prominences of the tarsal and metatarsal bones in chronic paralytic deformities.

(*f*) Over abnormal bony prominences, such as a "bunion" in hallux valgus and over exostoses.

CHAPTER XIV

GENERAL CONSIDERATIONS WITH REGARD TO INJURIES OF BONES

Surgical Anatomy. The outer surface of a bone is surrounded by the periosteum, which is a fibrous membrane, thick and vascular in the growing bone, but becoming thinner in the adult. At each end of the bone this periosteum is intimately attached to the epiphysis, the epiphyseal line and the capsule of the neighbouring joint, while elsewhere it is easily detached from the bone and consists of an outer fibrous layer and an inner cellular layer. It was at one time thought that the function of this periosteum was to assist in the formation and growth of bone, and it was considered that the cells known as osteoblasts, which are capable of the new formation of bone, belonged to the inner surface of the periosteum. It is, however, more likely that in the adult at any rate the function of the periosteum is to limit the formation of bone and that the osteoblasts are the superficial cells of the bone itself and are not part of the periosteum. It has been found experimentally that if the periosteum is detached from a bone with a blunt instrument and buried in the muscles, it gives rise to no new formation of bone, but if it is detached from the bone with a sharp instrument, so that possibly some of the superficial bone cells are scraped off, then when it is buried in the muscles new bone is formed. It is, however, possible that in children and adolescents, and when it is acutely inflamed, the periosteum is capable of bone formation. This will be discussed further in Chapter XVIII.

Nearly all the long bones of the body consist of a *shaft* and at their ends one or more *epiphyses*, and as long as the bone is still growing each epiphysis is joined to the shaft by a plate of cartilage known as the *epiphyseal cartilage*, the junction of this cartilage with the shaft of the bone being known as the diaphysio-epiphyseal junction. This epiphyseal cartilage provides the means whereby the bone grows in length, the growth occurring on the shaft side of the epiphyseal line, and in most long bones it will be found that the bulk of the growth occurs more at one end than the other and the process of growth continues longer at one end than at the other. When the growth of the bone is completed the epiphysis at either end unites with the shaft and the epiphyseal cartilage disappears, the age at which this occurs varying greatly in different bones. In the leg the most active growth occurs at the lower end of the femur and the upper end of the tibia and these epiphyses unite last, whereas in the arm it is the upper end of the humerus and the lower end of the radius and ulna which provide the bulk of the growth and take longest to unite.

The rate of activity of this epiphyseal growth may be modified profoundly as the result of injury or disease in the neighbourhood of the epiphyseal line (see also Chapter XVIII.). Displacements of the epiphyses which are not completely reduced may give rise to an irregular growth of the bone end which in time will lead to great deformity, as the whole limb may be thrown out of line.

Bone Grafts. As it is chiefly in connection with the results of injuries to bone that bone-grafting is employed, it is convenient here to consider certain pathological and physiological phenomena in this connection. Portions of dead bone, rods of ivory, etc., have been employed as grafts, but it is certain that such a graft simply acts as a splint, plays no active part in the process of bone regeneration and is ultimately absorbed by becoming pitted and eaten away by granulation tissue. Portions of bone which have been lost or destroyed as the result of an injury or disease may at times be reproduced, this new formation of bone being accomplished by means of the osteoblast cells which are found in the medulla and on the surface of the shaft of the bone. New formation of bone of this kind, however, is not usually very extensive, nor is it sufficient to fill a big gap. It only occurs in the long bones, and is not seen in the flat bones of the skull and face which are developed in membrane.

This power of bone cells to reproduce osseous tissue, even when moved away from their proper position, is the principle upon which the grafting of living bone depends, for it is found that a portion of living bone can be cut away from its surroundings and placed in a different position in the body in contact with other bone and there grow and become fixed and incorporated with the bone with which it is in contact, retaining its vitality and even exhibiting the power of growth and increase in size; this grafting of living bone, therefore, is preferable to the implanting of dead bone or foreign material. It must be admitted that certain pathologists consider that even when living bone is grafted in this fashion it merely acts as a scaffolding, takes no active part in the formation of bone growth, and often dies and becomes absorbed.

There is, however, little doubt that this is untrue and that, given favourable circumstances, the bone graft will live and grow. Cases have been recorded where a graft of this kind has been fractured after being in situ some time and has actually thrown out callus and united. A bone graft may be autogenous (taken from the patient himself), homogenous (taken from another patient), or heterogenous (taken from an animal), and there is no doubt that the autogenous grafts are the only ones likely to live and survive. There appears to be no limit to the size of an autogenous graft which may, under favourable circumstances, successfully be implanted. There is, however, unfortunately, considerable uncertainty about bone grafts, for it sometimes happens that an autogenous graft placed in position apparently under the most favourable circumstances fails to "take," does not become united, and after a time becomes absorbed and disappears.

There has been considerable discussion as to whether a bone graft should include either the medulla or the periosteum, and it is probable that if both the periosteum on its surface and a portion of the medulla on its inside are retained the establishment of a free vascular supply to the graft in a short time is easier and more certain, although it must be admitted that many grafts having neither periosteum nor medulla upon them have "taken" quite well. The smaller the graft is and the less it is handled and cooled the more likely it is to "take."

There are several different ways of inserting bone grafts:—

(*a*) Some surgeons recommend that fragments of living bone chipped into small pieces should be used, and that these should be dusted or packed into the required situation. We do not, however, regard this as a good method or as one more likely to achieve success than the other methods.

(*b*) A thin slice of bone, together with its periosteum, may be used in certain situations such as the skull.

(*c*) More commonly a massive graft is used consisting either of a complete section of a small bone such as a rib or the fibula, or else of a rectangular portion cut out of the crest or shaft of the tibia, retaining its periosteum and going into and including a portion of the medulla of the bone. In order to cut this latter type of graft satisfactorily, it is almost essential to be provided with Albee's circular electric saw, with either a double or single blade. (For a discussion of the shapes and types of grafts used, see p. 432.) If a living bone graft is to have any chance of success on implantation, four important points must be specially attended to:—

(*a*) Absolute asepsis is essential. The operation is, therefore, doomed to failure in cases of recent compound fractures.

(*b*) Hæmostasis must be as complete as possible in order that no hæmatoma may form.

(*c*) The graft must be fixed in position to the ends of the neighbouring bone as efficiently as possible.

(*d*) External splinting must be provided, which must be devised to produce the most absolute fixation and rest for the first three or four weeks until the graft has had a chance of uniting. Once union appears to have taken place active use and movements undoubtedly will stimulate the growth of bone and strengthen the graft, as, in accordance with Wolffe's Law, the growth of new bone and its structural formation depend upon the function it plays and the stresses and strains put upon it.

If an injury is slight in nature, no solution of continuity in the bone will occur, and a contusion of bone is the result.

With more severe injury solution of continuity is complete or partial, resulting in a fracture, which may be defined as a sudden change in the continuity of a bone.

Contusions of Bone. These tend to occur in those bones most exposed to trauma, and therefore are seen most commonly in the case of the ulna and tibia. The result of the injury is a subperiosteal hæmatoma, which may undergo complete absorption, but usually some degree of new bone is laid down in the area, resulting in a *periosteal node.* Such a hæmatoma, if of any size, has a great tendency to suppurate, infection reaching it either by the blood stream or an abrasion in the overlying skin. Even where the injury is of microscopic extent it will devitalise the bone, and in debilitated subjects, if bacteria are present in the blood stream, may result in a localised acute suppurative osteitis or osteoperiostitis. Slight trauma is stated to be a possible factor in the production of malignant disease and tuberculosis of bones. Locally bruising and swelling, with a point of maximum tenderness, are present. An X-ray film must be taken to exclude a subperiosteal fracture.

The *treatment* of a contusion consists in promoting absorption and keeping close watch for the onset of suppuration. Rest is the most important factor, and one that is apt to be forgotten, combined with the local application of a cooling lotion, such as lotio plumbi. Iodides are useful taken internally, as they tend to promote absorption. Early incision is indicated in the presence of suppuration, as by delay necrosis of the underlying bone is encouraged.

FRACTURES

Fractures may be (*a*) traumatic, when the lesion occurs in a previously healthy bone as the result of an injury, which is usually a severe force acting from without.

(*b*) Pathological, when the fracture occurs as the result of some diseased condition in the bone, with or without violence (see p. 406).

Traumatic Fractures. Ætiologically fractures are more common between the ages of twenty-five and forty, and in old age. Up to the age of seventy they are commonest in men, owing to their more severe occupations, but over seventy Colles' fracture and fracture of the neck of the femur give a preponderance to the female sex. In the young separation of epiphyses is more likely to occur.

The violence giving rise to a solution of continuity in a bone may be applied in three ways :—

1. Direct violence, applied at the actual point where the bone breaks. This usually gives rise to a transverse fracture, and is sometimes called a " fracture by compression " ; an illustration is a fracture of the leg produced by a wheel passing over it, or a fractured rib produced by a kick.

2. Indirect violence, which fractures the bone by torsion or leverage owing to a force applied some distance from the actual site of fracture, the bone usually giving way at its weakest spot, *e.g.*, a fractured clavicle.

3. Muscular violence, supplied by the patient through some forced and inco-ordinated muscular movement—a common example being the tearing off of a bony process such as the great tuberosity of the humerus, the transverse fracture of the patella due to sudden pull of the quadriceps in averting a fall backwards, a fracture of a rib by coughing, etc.

The line of the resulting fracture is in keeping with the type of violence applied. It may be **transverse,** as is usual in fractures due to direct violence, or it may be **spiral or oblique** in fractures due to indirect violence.

Occasionally it is **longitudinal,** but this is very rare, unless combined with one of the other three in a case of comminuted fracture.

Varieties of Fractures. Clinically the most important varieties of fractures are simple and compound.

(*a*) **Simple or Closed Fractures** are those where there is no wound in the skin and soft tissues which communicates with the broken ends of the bones. Such a fracture is sometimes complicated by a skin wound, which does not communicate with the fracture.

(*b*) **Compound or Open Fractures,** where the skin or mucous membrane is torn and the wound communicates with the fractured bone ends. The skin may be torn either by the force producing the fracture (*direct compound fracture*) or by one of the sharp fragments from within (*indirect compound fracture*). This wound communicating with the fracture gives rise to a grave risk of sepsis, this risk being far greater in the direct variety. In many cases an indirect compound fracture, if properly cleansed, will behave like a simple fracture.

All fractures may also be divided into other groups which depend upon (*a*) the direction of the break, (*b*) the nature of the damage done to the bone and the displacement the fragments have undergone.

(*a*) Considered from the point of view of the direction of the break, fractures consist of transverse, oblique, spiral, and longitudinal varieties, terms which explain themselves.

(*b*) When considered from the point of view of the bony damage and the position of the fragments, there are variations in the type of injury produced, depending to some extent upon the anatomical structure of the bone injured. So that we meet with :—

1. **Complete and incomplete fractures.**

2. **Greenstick fractures** in those persons, usually under 12, in whom calcification is not complete, or who are suffering from some disease in which calcification is incomplete, such as rickets, the bone bending and breaking on one side only in the manner implied by the name greenstick. These are, therefore, pre-eminently the fractures of childhood, and are seen especially in the forearm bones and the clavicle.

3. **Depressed fractures,** seen particularly in the flat bones of the skull. These may be of several varieties, such as the *pond* and *gutter* type.

4. **Fissured fractures,** occurring most frequently in the flat bones—*i.e.*, the skull, pelvis and scapula ; and into joint surfaces.

5. **Comminuted fractures,** in which the bone is broken up into several fragments ; these are usually due to severe direct violence and are seen in gunshot wounds and in railway and machinery accidents.

6. **Separation of epiphyses or bony processes,** such as the coracoid process or tuberosity of the os calcis.

7. **Subperiosteal fractures,** usually in children where the intact thick periosteum holds the fragments together.

8. **Complicated fractures,** in which there is damage to vessels, nerves and joints.

Displacement of the Fragments. The result of a fracture is a tendency to displacement of the fragments, which may take several forms :—

(*a*) There may be no displacement.

(*b*) The displacement may be angular, as in greenstick fractures, or consist of distraction and separation of the bone ends, overriding with shortening of the limb, rotation of one fragment upon another, or depression of the fragments, as in the skull or nasal bones.

(*c*) One fragment sometimes will be jammed or wedged into another, and thus firmly fixed. This is known as **impaction,** and is seen usually at the cancellous ends of the long bones.

These displacements are produced by and depend upon various factors :—

1. The nature and direction of the force causing the injury, which may push the fragments out of place.
2. Gravity. This usually acts upon the distal fragment and may cause it to fall, roll or drop into some abnormal position.
3. The contraction and spasm of muscle groups ; this is an important cause, for it usually produces displacements which in any particular fracture are typical, and can be foretold to a certain extent.
4. Rough handling and incorrect treatment and splintage sometimes will alter or increase the deformity.
5. The shape and direction of the fractured bone ends will modify displacements considerably ; thus oblique and spiral fractures are specially liable to longitudinal displacements and transverse fractures to angulation.

Pathological Fractures. The vast majority of fractures occur in bones which were previously normal, but occasionally some diseased condition of the bone weakens it so that it breaks as the result of a minimal degree of violence which would not break a healthy bone ; this condition, therefore, always should be suspected and verified by X-rays if a bone appears to have broken as the result of very slight violence. Intrauterine fractures are occasionally seen which fall under this heading.

The causes of pathological fractures are :—

1. Simple atrophy of bone. This may be due to poor blood supply, as in old or bedridden people, *e.g.*, the neck of the femur in elderly women. In other cases an aneurysm or tumour may press upon and erode the bone, while in certain diseases of the nervous system, such as tabes, G.P.I., and others, extensive bony atrophy will occur.
2. Diseases affecting a solitary bone, such as osteitis, whatever its cause, fibrocystic disease and hydatid cysts, gummata and new growths, especially sarcoma and secondary carcinoma or hypernephroma. A sudden fracture of a bone is often the first sign of a new growth which is involving it.
3. Diseases affecting the whole skeleton, such as rickets, osteomalacia, myelomatosis, fragilitas ossium, and fibrocystic disease. These diseases are liable to give rise to multiple fractures, which may unite readily.

Clinical Features of Fractures. The history may be of the greatest assistance, as by a careful inquiry concerning the accident it is often possible to forecast the lesion which has occurred. Special attention should be paid to the nature of the violence, the agent producing it, the position of the limb and state of contraction of the muscles at the time, and the patient's feelings and sensations. A not uncommon example is that of an elderly lady tripping over the edge of a badly laid carpet, thereby sustaining a fracture of the neck of the femur.

The *signs and symptoms of a fracture* are :—

1. *Pain.* This is a valuable symptom. It may be localised to the site of the fracture, where it may be constant, or be elicited only by manipulation, or it may be referred elsewhere. If pain occurs quite definitely at some spot other than the part of the body to which the violence was applied, it is highly suggestive of a fracture, *e.g.*, pain in the clavicle following a fall on the hand. But it must be remembered that pain at the site of the injury may be due to many other conditions besides a fracture ; especially is this so if the pain is independent of attempts at movement. A definite point of tenderness on a

bone is also suggestive of fracture. Still more so is the occurrence of pain at one part of a bone when some other spot on the bone is pressed upon, *e.g.*, pain near the neck of the fibula, when its lower end is pressed upon, and *vice versâ*.

2. *Local tenderness* is mentioned on p. 406.

3. *Local swelling,* due to hæmorrhage, œdema and bruising. This comes on rapidly within a few hours, spreads far and wide, and if the case is not seen early may make the diagnosis difficult. Not infrequently bruising and discoloration appear some days later, and at a distance from the site of a deeply placed fracture. By the force of the injury or the moving of jagged fragments vessels are ruptured and extravasations occur in the soft tissues, and these, by pressure, still further impede the circulation so that œdema results. This swelling hampers effective reduction of the fracture, especially where it is under great tension, as when it is within the aponeurotic sheath of a limb in the case of fracture of one of the long bones.

In association with the widespread discoloration and bruising of the skin, and especially on the leg, blebs containing bloodstained serum form upon the surface, and these are very characteristic of a fracture, while all bony landmarks tend to become obliterated.

4. *Crepitus.* This is a very important and, when detected, diagnostic sign of fracture, but no undue effort should be made to elicit it, as much harm may be done thereby, and if other points clinch the diagnosis of fracture it need not be tested for. It is caused by the rubbing together of the fractured bone ends, and consists of a peculiar grating or clicking. It is important to remember that crepitus may occur in other conditions; thus in separation of an epiphysis it is peculiarly soft, and is known as muffled crepitus. A creaking sensation is sometimes felt in dislocations; osteoarthritic joints will crackle, while a tenosynovitis will give rise to a fine, silky crepitus, effusions of blood occasionally crepitate, and the presence of air in the tissues, due either to surgical emphysema or infection by gas-producing organisms, produces a distinct type of crepitus (see p. 225). Crepitus will be absent in a fracture if it is impacted, if the fragments are not in contact with one another, or if the fracture is incomplete.

5. *Unnatural mobility, i e.*, movement at some point in the limb where there should be no movement. Impaction, incompleteness of the fracture, and swelling over the surrounding tissues may prevent this sign being detected.

6. *Deformity:* often obvious to the eye, but to be checked by measurements and by noting alterations of important bony points in comparison with the sound side; it is of the nature of angulation, shortening, etc. This will be absent if there is no displacement or if only one of two parallel bones is broken.

7. *Interference with function.* This, however, may be completely absent if firm impaction of the fragments is present, if the fracture is incomplete, or if only one of two parallel bones is fractured.

The diagnosis of a fracture (having taken the foregoing into consideration) will be clinched by an X-ray examination.

Of the above-described clinical signs and symptoms only three—crepitus, deformity, and unnatural mobility—are in any way conclusive evidence of a fracture; one or more of these signs may be absent from a fracture, while the other features described are at best only indirect evidence.

X-ray Examination. This always must be carried out as soon as possible, as it will assist by confirming or making the diagnosis of a fracture, by checking position during treatment, and by giving definite ocular evidence should medico-legal proceedings supervene. In view of the ruling of the medical defence societies and of the findings in the Courts, the necessity for an X-ray photograph even in all cases of suspected fracture cannot be too strongly impressed on the practitioner, who always should obtain a written admission from the patient of his or her refusal to submit to an X-ray examination.

It must be stressed, however, that clinical diagnosis should always come first, and no time should be lost in undertaking treatment because an X-ray photograph is not immediately available, for, like any other surgical emergency, fractures should be treated as soon as possible; delay is criminal. Nor is an X-ray plate infallible, for it is most important to have two plates taken in different planes, if possible at right angles to one another, as often a fracture may not show at all in an antero-posterior plane and yet be perfectly obvious in a lateral view. This, of course, applies with equal force to the results of attempted reduction of a fracture, the success or failure of which should never be judged by a view in one plane only.

In some cases, such as a fracture of the neck of the femur and injuries of the carpus, it will be found of great service if a stereoscopic picture is taken. It is important that any person who is going to pronounce a verdict on an X-ray photograph should be thoroughly conversant with the appearance of normal bones, as epiphyseal lines and common abnormalities may lead to mistakes. A fertile source of confusion, and even of legal procedure, is the os trigonum tarsi. In all doubtful cases an X-ray film of the sound side should be taken and compared carefully with the injured limb.

In certain cases it is essential to have a portable X-ray outfit in order to check the treatment of a fracture in a patient too ill to be moved or undergoing treatment in some form of apparatus which precludes movement from the ward to a special department, while in this connection it must be emphasised that actual plates or films always should be taken, the evidence of a screen being valueless. It may be necessary, particularly in children, to have recourse to a general anæsthetic in order to obtain a satisfactory photograph. Most of the splints in use at the present time are pervious to X-rays, and this always should be the case, as it is valueless and foolish to tamper with a fracture after efficient reduction in order to photograph it. Plaster of Paris, skeleton splints, and those made of aluminium composition are all suitable.

It cannot be insisted too strongly that X-ray photographs must be taken of all injuries after reduction.

The X-rays are further of use to check the progress of union. Callus will begin to show sometimes in ten to twenty days as a vague fluffiness, gradually becoming more definite in appearance, and later, at the stage where union is complete, assuming the laminated texture of normal bone.

General Effects of Fractures. *Shock* may be trifling or severe, depending on the bone broken, the force of the injury, the presence of associated injuries, and the age and general condition of the patient. It is augmented by delay in efficient treatment and consequent jarring of the affected parts, and is always severe in compound fractures.

Hæmorrhage is very rarely severe enough to give rise to constitutional effects unless some large artery is ruptured.

Aseptic Traumatic Fever. Some degree of pyrexia (99° to 100°) is almost constant after a fracture, although it is never severe. It occurs for the first forty-eight hours, and, resembling the fever following burns, is probably due to autolysis and absorption of the products of dead tissue.

Complications. 1. *Injury to arteries* is uncommon; it may be produced either by the force of the injury or by one of the jagged fragments of bone. Where hæmorrhage occurs among muscles deep to tense fascia the resulting pressure may cause Volkman's ischæmic contracture, and in all such cases early incision through the fascia is called for to relieve pressure on the vessels. It is usually seen in compound fractures due to gunshot wounds or in fractures of the lower end of the femur. When this occurs there is a tendency for gangrene to supervene, primarily of the dry type, but, if the venous return is impaired, becoming moist (see pp. 153–155). In compound fractures an arterial injury greatly increases the liability to gas gangrene.

In a compound fracture the risks of secondary hæmorrhage from coexistent sepsis are considerable (see p. 51).

A pulsating hæmatoma, or later a traumatic aneurysm, may develop at the site of the injury (see p. 260), especially in simple fractures.

Treatment will be directed to tying the injured vessel, as reparative surgery of the artery is rarely feasible (see p. 278). The opportunity should be taken of dealing, if necessary, with the fracture at the same time.

2. *Injury to veins* is always present to some considerable degree, and produces the characteristic bruising and extravasation; any hæmatoma which follows will be controlled by early and efficient treatment. The impaired venous return is partly responsible for the œdema which invariably follows a fracture.

3. *Injury to nerves* (see Chapter XII.). These may be either partially or, very rarely, completely torn at the time of injury, or compressed by the inflammatory changes, but usually a nerve injury is a late complication, coming on about the third week, and due to compression of the nerve by young scar and granulation tissue, or improperly applied splints. This latter type tends to clear up spontaneously in from one to three months, but should receive proper electrical treatment.

The treatment is expectant, but if the symptoms persist and there are signs of complete physiological interruption in the nerve, it should be exposed and dealt with as necessary (see p. 334). Here, again, if required, the fracture may be dealt with at the same time.

Crutch Palsy is another complication seen after fractures, and is due to compression of nerves by the continued use of ill-fitting crutches pressing upon the brachial plexus (see p. 360). The nerve affected is the musculospiral, as shown by the onset of wrist drop. Once the condition has developed, proper splintage, massage and electrical treatment should be given. Recovery is usually complete. The condition, however, always can be avoided, for elbow crutches are preferable to the old-fashioned type.

4. *Involvement of joints.* This results in a hæmarthrosis which, though tending to absorb in time, may give rise to adhesions within the joint, especially if the joint surfaces are extensively damaged. Where this is the case, particularly in elderly subjects, troublesome arthritis is likely to develop later. In compound fractures there is always the risk of septic arthritis supervening. Even more troublesome than effusion into the joint itself is the extravasation into and tearing of the capsule, ligaments, and muscles around it, giving rise to dense adhesions producing gross limitation of movement. If union of a fracture near a joint occurs in faulty position, so that abnormal strain is thrown upon the joint surfaces, then troublesome recurring effusion and chronic arthritis will develop. If the synovial fluid from the joint has free access between two fractured surfaces, then non-union is the rule, the carpal scaphoid being a good example.

Fractures involving joints are best treated by immobilisation until some consolidation of the fracture has occurred. This occurs usually in about three weeks. It is not uncommon, especially in the region of the upper end of the humerus, to see a *fracture associated with a dislocation*. Such a dislocation always must be reduced at once, and the fracture then be dealt with on the usual lines. Should reduction prove impossible, then recourse must be taken to open operation.

5. *Pulmonary embolism* is seen, as might be expected, occasionally after a fracture, especially those where large veins are injured.

6. *Fat embolism*, usually of the pulmonary type, may be seen after a fracture. The sooner adequate fixation is obtained the less likely is this to occur.

7. *Pressure sores* may be produced by badly fitting and ill-applied splints, while in cases confined to bed the ordinary bedsore may prove a troublesome complication. They are treated by removal of all pressure while the wound is kept aseptic.

8. *Gangrene* (see p. 152) may occur, either from the immediate injury leading to gross destruction of tissue, from injury of arteries and extensive thrombosis, owing to sepsis in a compound fracture, or to faulty treatment in the form of tight bandaging and splintage. In all cases of fracture the pulse in the limb distal to the site of fracture must be watched carefully.

9. *Delirium tremens* (see p. 17) is not infrequently seen. Warning of its onset is usually present, and vigorous prophylactic measures should be instituted.

Volkmann's Ischæmic Contracture. This is a muscular lesion and is usually seen in the flexor muscles of the forearm following a fracture of the lower end of the humerus, or of the bones of the forearm. It is also occasionally seen in the calf and the thigh. Impairment of blood supply produces a necrobiosis in the muscle, with consequent fibrosis and shortening.

The condition is produced by hæmorrhage into the muscles or by excessively tight bandaging or splintage; hence after reduction of such a fracture the fingers, and the radial pulse also, always should be left accessible so that the circulation may be watched carefully. If the circulation remains impaired in spite of reducing the fracture, an incision should be made through the deep fascia of the antecubital space to evacuate the hæmatoma and relieve the pressure on the vessels.

Clinically the condition appears rapidly with a sensation of tightness and stiffness on attempting to move the muscles affected, if these signs are neglected then in about the third week the established condition is obvious, and is manifested by inability to extend the fingers unless the wrist is flexed first (Fig. 200).

The treatment consists in the early stage in prompt incision to relieve tension, but in the established condition is tedious and unsatisfactory, consisting in immediate release of all splints and gradual stretching of the muscles; in some cases the tendons may be lengthened, and in others the origin of the flexor muscles slid down; by shortening the bones by open operation the muscles may be rendered capable of resuming their functions.

Traumatic Myositis Ossificans sometimes occurs; this is seen most often in the brachialis anticus muscle in the region of the coronoid process of the ulna, following a partial detachment of this process associated with posterior dislocation of the elbow. The periosteum is torn and allows the escape of osteoblasts into the soft tissues, with consequent osteoid formation. Painful limitation of flexion results from the big mass of bone which forms in front of the joint, and which can be seen in an X-ray plate, while the only treatment is absolute immobilisation, when the condition will consolidate and slowly subside. Movement or attempts at surgical removal are followed by further excessive output of bony tissue. This occasionally gives rise to difficulty in diagnosis from a periosteal sarcoma (pp. 577 and 580 and Figs. 300 and 301).

SEPARATION OF EPIPHYSES

These injuries occur in young patients whose epiphyses have not yet united, from violence affecting the ends of long bones, this violence being usually indirect, combined with torsion, and of the type which in an adult would produce a dislocation. Direct and muscular violence are rare causes. Though usually entirely due to trauma, pathological separation of epiphyses is seen as the result of disease at that site due to tuberculosis, rickets, acute osteitis, scurvy, congenital syphilis or tumours.

The frequency with which the various epiphyses are affected is as follows :—

The lower end of the radius, the upper end of the humerus, the lower end of the humerus, the lower end of the tibia, and the lower end of the femur. The commonest ages at which these injuries occur are between ten and eighteen, while they do not occur at all after twenty-five. They are rare in females ; occasionally multiple epiphyseal separations are seen.

In the very young the line of cleavage is purely epiphyseal, but later in life the line of cleavage tends to run up into the diaphysis at some point, so that the injury is partially a true fracture. In a pure separation the epiphyseal cartilage remains attached to the epiphysis.

The periosteum is stripped up and may form a splint, retaining the fragments in position. If perforated or buttonholed by one of the fragments, the sleeve of periosteum is a troublesome obstacle to reduction.

Separation of an epiphysis may be complete or incomplete, simple or compound ; incomplete separations are sometimes known as the "juxta-epiphyseal strain of Ollier."

Clinically these injuries resemble either dislocations or fractures ; deformity is usually slight because of the periosteal support given to the fragments ; unnatural mobility is marked, but takes place very close to a joint where there is natural mobility ; the crepitus associated with these injuries is of a peculiar "muffled or soft" nature. Pain and tenderness will be present along the epiphyseal line, while swelling, ecchymosis and effusion of fluid into the neighbouring joint will be found. In small children loss of power in the limb often will be the only sign (pseudo-paralysis). In most cases the relationship of the bony points will settle the diagnosis, as also will an X-ray picture.

Most commonly satisfactory bony union occurs, though as these lesions always occur near joints, the chances of stiffness or limited joint mobility are increased. Complete arrest of or irregular growth of the bone is liable to occur, as a result either of premature synostosis of the epiphysis or, more commonly, of diminished power of bone growth. This may lead to marked shortening, or in the case of segments of a limb where two bones are present to marked lateral deformity.

Partial separations are often overlooked, and may then give rise to bending of the end of the bone later (*e.g.*, one form of coxa vara). Very occasionally complications such as pressure upon arteries or nerves or suppuration (from organisms in the blood stream) will occur.

Treatment. The treatment of these injuries resembles that of fractures; accurate reduction is of the greatest importance. This occurs without the typical snap felt in a dislocation, while there is a great tendency for the parts to slip out of alignment again. Operation is thus not infrequently required.

REPAIR OF FRACTURES

Normal Repair. The immediate result of a fracture is a collection of blood around the torn periosteum and the broken ends of the bone. The blood and the resulting clot form a scaffolding which becomes permeated by fibroblasts, leucocytes, and newly formed blood vessels, giving rise to the development of young granulation tissue in an exactly similar manner to the healing process in any other part of the body (see p. 45), the periosteum taking a very active part in this process and becoming vascularised and thickened. The difference between this and the healing of a wound of the soft tissues lies in the fact that here matters are carried further. Bone-producing cells, very similar to fibroblasts and known as osteoblasts, invade the granulation tissue and lay down a calcified osteoid tissue, which is known as *callus*, which may be formed direct, but which sometimes passes through an intermediate stage of cartilage, especially in young persons; this is ultimately converted into normal bony tissue by the same process that produces ossification in the cartilage of a growing bone. The callus begins to make its appearance about the tenth day after a fracture. It appears first on the outer or subperiosteal aspect, where it gives rise to a rounded swelling, and is known as the *external or ensheathing callus.* Callus next appears in the plug of granulation tissue filling the exposed medullary cavity, being there known as the *internal callus*, and, lastly, it appears between the ends of the compact bone itself, this portion being called the *definitive or permanent callus ;* this latter part of the callus is the only portion which persists, the external and internal callus being later absorbed by giant cells. It is, therefore, obvious that for strong bony union to occur perfect anatomical reposition of the fractured ends is essential. Clinically callus will manifest itself about the third week, and after this time, although angulation may set in as the callus is still soft and malleable, separation of the fractured ends is unlikely to occur. At this stage a spindle-shaped swelling is palpable at the site of the fracture, which in process of time becomes more definite, harder, and gradually smaller until ultimately nothing may be detected clinically, though on X-ray examination some evidence will persist for many years. This shrinkage of the swelling corresponds to the replacement of the callus by true bone, and the absorption of the excessive external and internal callus.

FIG. 211. Transverse fracture, showing repair and callus.

Much less callus is formed from those bones, such as the skull, which are developed in membrane than from the ordinary long bones which are developed in cartilage.

If comminution is present or if reduction is imperfect, much more callus will persist, the new bone being laid down in a manner best suited to bear stresses and strains in the faulty position and acting as a buttress to the bone. Such an excess of callus near a joint may limit severely the movements of that joint.

If muscle or synovial fluid is interposed between the fractured ends, or if they are widely separated, then non-union will result, as the callus may not be able to bridge the gap.

Occasionally, usually as a result of excessive irritation, or mobility of the bone ends, an undue amount of callus will be formed, and give rise to a large, hard, painless tumour at the site of the injury, which is sometimes known as an **osteoma fracturæ** or a **callus tumour.** In other cases it sometimes happens that if an acute fever supervenes while a fracture is undergoing repair, the callus may become absorbed and the fragments again become movable.

Certain factors have an influence on the rate at which union occurs. As regards age, fractures heal relatively quicker in childhood, otherwise no difference between the young and the aged can be detected.

The speed of union tends to be increased by comminution, provided that the comminuted fragments remain attached to the periosteum, the excessive damage to the bone helping to pour out quantities of osteoblasts.

The vascularity of the fractured ends has a noticeable effect. The fragment which possesses the nutrient artery tends to throw out more callus, and a relatively avascular structure like the head of the femur is slow in uniting.

A moderate amount of play between the fractured ends promotes union and callus formation, and it is for this reason that non-union is unknown in the case of the ribs.

Equally or more important than the healing of the injury to the bone is the repair that takes place in the surrounding soft parts. These in a similar manner heal by fibrosis, which is commonly extensive. Tendons tend to become adherent to their sheaths and muscles become shortened and fixed to the bone. The troublesome limitation of movement in the knee joint which commonly occurs after a fracture of the shaft of the femur is usually due to adherence of the quadriceps muscle to the femur.

Extensive periarticular fibrosis of joints also may occur and give rise to severe disability, while, as mentioned above, nerves may be caught up and damaged in the healing process.

Faulty Repair of Fractures.

(1) **Delayed Union.** The time taken for the healing of a bone varies within wide limits in different bones, in different portions of the same bone, and in different patients. A fracture should for arbitrary purposes not be considered past hope of union until twelve months have elapsed. Active bone disease, such as rickets, will delay union. Syphilis also has this effect, as has also any general condition lowering the reparative processes of the body, such as tuberculosis, diabetes, the anæmias, or chronic renal disease. The presence of sepsis and resulting sclerosis of the bone will have a similar effect.

Local treatment consists in encouraging the vascularity of the part by massage and rubbing the fractured ends together, while passive congestion should also be tried. This is carried out by applying an elastic bandage above the fracture, sufficiently tight to obstruct the venous return, but not tight enough to obstruct the arterial supply (see p. 28). It should be given for two out of the twenty-four hours, and be followed by massage. Active function should be encouraged. In the case of the lower extremity weight should be borne by means of an ambulatory plaster or a walking caliper splint. Other methods of treatment consist in the administration of phosphorus or thyroid extract, drilling the bone ends or the injection between the bone ends of sterile whole blood or oil of turpentine.

The general health should be improved, and if such a factor as syphilis is present energetic treatment instituted.

(2) **Fibrous Union.** In some cases, as in a fracture of the patella or olecranon not subjected to operation, this is the usual means of repair, and if care is taken in the early part of the treatment to prevent undue stretching of the young fibrous tissue, a perfect functional result is obtained. In the long bones the fibrous tissue is seldom strong enough, and the case has to be treated as if union had not occurred.

Where gross pieces of bone are destroyed, as in a gunshot wound or following necrosis secondary to infection, a strand of fibrous tissue is all that connects the bone ends.

If very free movement is allowed between the fractured ends, as is seen most often in a fracture of the shaft of the humerus, the bone ends become sclerosed, rounded and covered with cartilage, and in the fibrous tissue joining the two ends a **false joint or pseudarthrosis** develops, with a shining secretory membrane surrounding it. Such false joints are seen chiefly in the humerus, the clavicle and the tibia.

(3) **Non-union.** Here the same factors are at work as are responsible for delayed union, and the condition is therefore due to :—

(*a*) *Gross lack of fixation of the fragments.*

(*b*) *Local causes secondary to the injury.* Such are either free access of synovial fluid between the fractured ends, as occurs in the carpal scaphoid, or in a fracture through the narrow part of the neck of the femur ; or the interposition of masses of soft tissue, usually muscle, between the fractured ends, or the destruction of such large masses of the bone that coaptation of the fractured surfaces cannot occur—in other words, distraction of the fragments. In some cases lack of rest or a defective blood supply, possibly due to damage to the nutrient artery, may be responsible.

(*c*) *Local disease of the bone,* such as sepsis producing necrosis and later sclerosis of the bone. A tuberculous osteitis or localised gumma also will produce non-union ; while the bones in tabes and certain other diseases of the nervous system are liable to non-union.

(*d*) *General disease of the bone,* such as rickets, osteomalacia, fragilitas ossium, and scurvy.

(*e*) *General conditions,* such as severe anæmia, wasting diseases and syphilis, diabetes, tuberculous and chronic renal disease.

To recapitulate, the common causes are (1) interposition of soft parts, (2) sepsis, (3) syphilis.

Treatment. If the case comes under observation for the first time, the methods advocated under delayed union should be tried. Should this have been done without result, then resort must be had to operation. Any operation must aim at apposition of normal bony tissue, otherwise failure will be the result, and there must, therefore, be free removal of all fibrous tissues and sclerosed unhealthy bone, so that firm contact between the fractured surfaces can occur. This holds good whether the two ends are got into apposition by shortening the limb or continuity is established by means of a graft. Before proceeding to operation it must be ascertained that no local sepsis is still active, and this can be done by a course of local irritation with a vibrator. No septic focus, such as a boil, should be present elsewhere in the body. Special precautions should be taken in old gunshot wounds against the lighting up of latent sepsis or of latent tetanus, a prophylactic dose of antitetanic serum being given before operation.

(4) **Malunion.** In certain cases union may have occurred in such bad position or such an excess of callus be present that, to ensure good function, refracture must be produced. Malunion of this nature is often due to improper treatment, faulty reduction, and inefficient splintage; it may occur, however, because of excessive comminution, or because the patient was restless, maniacal, or having "the horrors," or because it was thought he was going to die and so the fracture was not treated. In such a case the amount of interference with function must be considered in deciding whether a refracture is the best treatment for the patient. If refracture is decided upon, if the callus is soft and the fracture comparatively recent (less than four weeks), it may be possible to bend or break the bone with the hands or with an osteoclast; but in later cases (and in most cases) heavy traction with a Kirschner's wire or open operation will be necessary. The bone must be either simply divided with an osteotome or have a wedge-shaped portion removed; it will then be put straight and fixed by some form of internal and external splintage (see p. 431).

TREATMENT OF FRACTURES

Reduction. In the vast majority of cases some degree of deformity and displacement of the fragments is present, and to correct this reduction is necessary. As stated above, this should be done as soon as possible after the receipt of the injury. This reduction aims at overcoming any deformity, which usually means abolishing spasm of muscles, with consequent shortening. If impaction in proper position is present, reduction is, of course, unnecessary. It may be effected in the following ways:—

1. *By Manipulation.* Occasionally this can be performed while engaging the patient in conversation, but usually some form of anæsthesia will be found necessary. In the hands of an expert this can be supplied in the form of massage, for a short sitting of light massage will abolish muscular spasm and produce a blunting of sensation in the parts sufficient for the reduction of certain fractures. This method, however, requires both patience and a high degree of technical skill.

2. *By Manipulation under Anæsthesia.* The anæsthetic most commonly used is gas and oxygen or ether, for where complete relaxation of spasm is required or proceedings are likely to be prolonged a general anæsthetic must be administered. This should never be done light-heartedly, but the patient be carefully prepared beforehand, for in this way occasional disaster will be avoided. In using nitrous oxide it will be found, once the patient is fully anæsthetised, that a point is reached where the muscles are felt to relax, and this is the optimum time for reduction. Most fractures can be reduced with a local anæsthetic injected in between the bone fragments or round the principal nerves proximal to the fracture (Böhler).

3. *By Gradual Extension.* In those cases where it has been impossible to treat the fracture at once, and where shortening is present, it will be found that extensive reactionary swelling and œdema have occurred, precluding any likelihood of success in immediate reduction. These cases demand that

a weight extension should be applied and, if possible, massage instituted. In this way spasm and œdema are relieved and the fragments tend to take up good alignment. Modern methods of extension by means of Kirschner's wire, etc., will reduce almost any fracture if properly applied. In the ordinary "putting up" of a fracture by manipulation, forcible extension with the hands plays a very important part.

4. *By Open Operation.* This, speaking generally, is a trump card, only to be played in grave necessity, after other methods have failed; it should not be employed as a routine method, although it must be admitted some authorities do not hold this view. It introduces an added element of risk, converting a simple fracture into a compound one, and requires a high degree of surgical skill. Sometimes it is impossible to disentangle soft tissues nipped between the fragments, and this is the usual factor rendering operation necessary.

There are, however, a few isolated fractures to be discussed later in which operation is the best treatment.

Fixation. Once the fractured ends are in such position that the surgeon is satisfied, it is necessary to ensure that the displacement will not occur again, and, therefore, some method of fixation is necessary, this may be external or internal fixation, and it must take into account the nature of the displacement to be guarded against and the causes of this displacement.

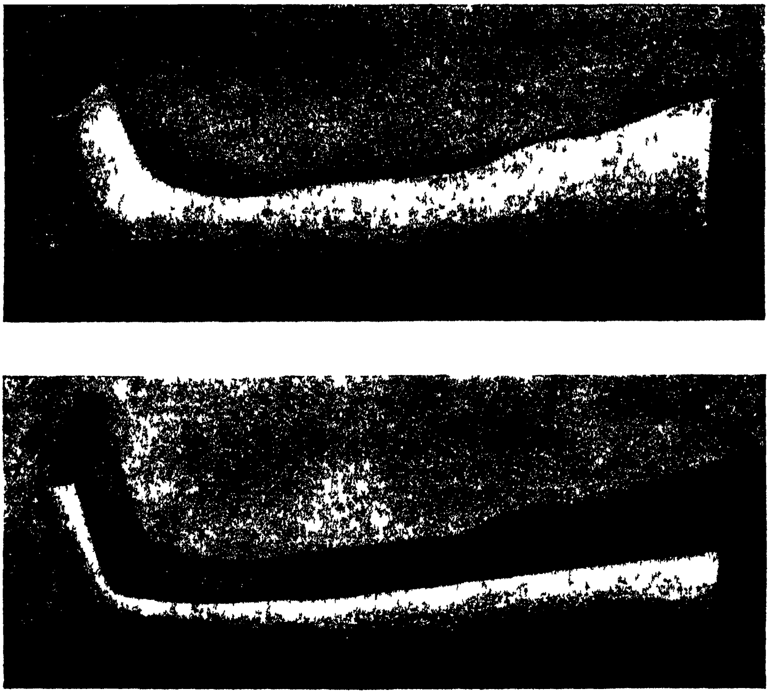


Fig. 212. Plaster splint before and after bivalving.

By external fixation we mean splints; by internal fixation, open operation and insertion of mechanical fixation. Internal fixation should never be relied upon alone, and after its use a limb should be splinted externally just as carefully as if no operation had been performed.

The following may be regarded as the essentials for a good external splint :—

1. Sufficient rigidity to support the weight of the limb.
2. Malleability to allow moulding to the shape of the limb, and to prevent undue pressure on bony points, but allowing extension of the fragments to be maintained by the splint between these.
3. Length sufficient to fix the joints above and below the point of fracture.
4. Permeability to X-rays.
5. Possibility of physio-therapy without removal of the splint.

It will thus be seen that of the many types of external splint in use, extension skeletal splints are the most ideal, but for practical purposes plaster of Paris is often preferable, though it does not allow of the fifth essential being carried out.

In connection with splintage it always must be remembered that in certain fractures the position in which the limb is placed will aid considerably both in the reduction and retention of the fragments in position, as by these special postures certain muscle groups which may be responsible for the deformity can be relaxed.

The following methods of external fixation are those in common use :—

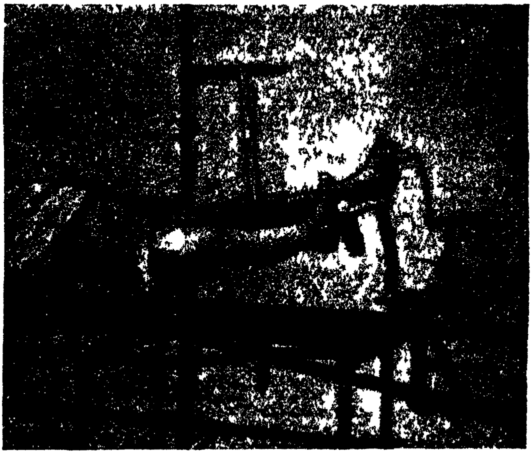


Fig. 213. Hawley table in use.

1. *Plaster of Paris.* This is a very valuable method of splintage, and one that is not used to the extent to which its merits entitle it.

It can be employed for the manufacture of gutter splints, which can be moulded to the limb with great accuracy, or it can be used to envelop the limb in a complete plaster casing. In these cases it is usual, when the time comes to remove the casing, to split it into two halves and retain one half as a gutter splint, which can be removed for massage, etc., and then reapplied (Fig. 212).

Plaster slats (gutter splints) may be made in the first place by using roller bandages as a sandwich, *i.e.*, rolling them backwards and forwards on their own length for the required distance up to six or eight thicknesses and then moulding to the limb.

The above remarks apply to its use in those fractures where angulation only is to be feared. It also can be used to control fractures in which shortening is likely to occur, if it is applied and carefully moulded so as to fit round bony prominences, while extension is being exerted. Such extension must not be removed until the plaster has set. Extension will then be maintained by the plaster splint.

For the latter purpose it is of infinite service to have a specially designed table, such as that of Hawley (Fig. 213) or Putti, upon which extension is maintained, while at the same time free access to the limb for the application of the plaster is ensured.

It should be stressed that in the case of plaster it is of vital importance to have the limb efficiently padded.

Before applying it the limb should be cleaned, for preference shaved, and dusting powder applied. Reactionary œdema and the presence of blebs on the skin are no contra-indication to its application; they merely signify that in two or three days' time it will be necessary to apply a fresh plaster, owing to shrinkage of the limb. The policy of "waiting until the swelling has gone down" is to be condemned ruthlessly.

First the padding is applied, the most convenient form being a layer of stockinette, cut to the requisite length and allowing enough to turn over at each end, which is pulled over the limb. If swelling is unlikely to occur, as in a case where a plaster which has become too loose from subsidence of reactionary swelling is being replaced by a fresh one, this will be all the padding necessary. If, however, swelling is likely, it should be further covered evenly with a layer of wool made up in the form of woollen roller bandages.

The desideratum is to have the plaster of uniform thickness throughout, for this ensures strength. Four thicknesses of bandage at any one point should be aimed at, of which the first layer is applied loosely, and each succeeding layer with increasing tightness, so that the plaster cream oozes up through the pores of the bandage. Each layer is rubbed over with the hand till smooth and, if necessary, a little plaster cream rubbed in. Great care must be taken to mould the plaster to the shape of the limb, especially over the bone ends, so as to ensure that extension will be maintained on the fragments at the site of fracture when the plaster has set, and so prevent overlapping when the patient is removed from the extension table. If any plaster is to be considered successful, it should have set absolutely firm within ten minutes of its application.

The bandages are made of muslin or linen and are packed with plaster powder, preferably Terrey's Italian Fine. They should be prepared freshly and not rolled too tightly, as in this case they will not absorb water efficiently. Where the freshness of bandages is in question, it is a wise precaution to place them in an open tin before a fire to ensure their being perfectly dry. They should be soaked in lukewarm water, to which, if desired, some salt may be added. They should not be wrung out before application, this effect being produced by tight application of the outer layers. The common fault in putting on a plaster is to have too much plaster and too little water, and not to take precautions that both are evenly distributed. It is very important to have this cream of correct consistence, as its use is of wide application, an average mixture being four parts of plaster to three of water. The mixture is well stirred and should be used at once, as it sets rapidly.

If necessary, points likely to be subjected to excessive strain may be strengthened by the insertion of strips of wood or malleable metal, or a sandwich made by rolling a wet plaster bandage backwards and forwards upon its own length.

These methods also may be used in designing skeleton plaster splints in which part of the limb has to be left exposed for dressing an open wound, and in this case it is well to have a layer of sheet rubber next to the skin in the region of the wound. This can be rolled over the edges of the "window," preventing fouling of the plaster.

As a plaster tends to contract on setting, a careful watch should be kept for the first forty-eight hours for any interference with the circulation below the plaster . if necessary it must be removed and a fresh one applied.

There should be free access of air to the plaster after it has been applied so that drying is not interfered with, but it is unnecessary to apply any heat. If the plaster has not set almost immediately after application, it must be accounted a failure.

Any trimming that has to be done should be carried out before the plaster has set, and in those cases where angulation only is to be feared it is safer to bivalve the plaster from the commencement. While the plaster is setting it can be cut away easily as desired by means of a sharp plaster knife.

In those cases where extension is being applied while the plaster is put on extra care must be taken that the padding is efficient A good method is to apply padding in the usual way and put the foot and ankle in plaster, leaving several turns of bandage long and loose. In this manner a plaster boot with a loop capable of exerting a powerful pull is made, while another method is to envelop the foot and ankle completely in a " boot " of ½-inch felt. Pull is then exerted over this with a bandage or worsted hitch (Fig. 214).

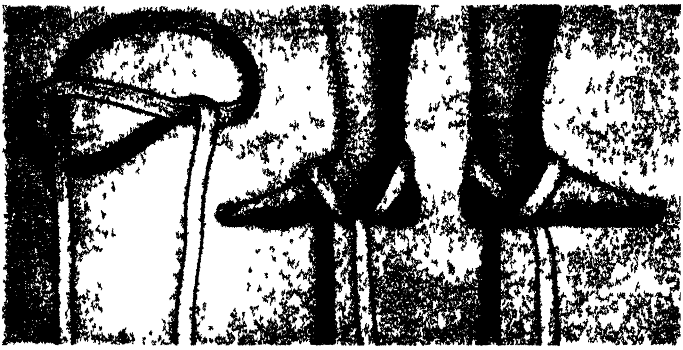


FIG. 214. Ankle hitch for exerting traction.

It is dangerous to apply any form of hitch over ordinary wool padding, even if it is cut and removed before encasing the ankle finally in plaster, for, if any part of the plaster has covered the hitch while under tension, it will have set in the groove formed thereby and will continue to exert pressure even after the hitch is withdrawn.

Plaster gutter splints can be made also by Croft's method. Pieces of Bavarian flannel are cut to the shape of the limb, and are then well soaked in and wrung out of plaster cream; they are then moulded firmly to the limb and are fixed with an ordinary roller bandage. They do not afford such firm fixation as a gutter made by the roller method.

A closely allied method of making gutter splints is by cutting out a pattern of paper and from this a piece of poroplastic felt. This is softened in steam, moulded to the limb, and fixed with bandages impregnated with starch paste. Cardboard may be used also in conjunction with starch bandages.

2. *Skeleton Splints.* These are peculiarly suited to those cases where the limb must be freely accessible for the dressing of open wounds, or the application of physical methods of treatment or when gradual reduction of the

fracture is desirable. It is also the standard method where it is necessary to apply continuous extension to a fracture.

In these cases fixation is produced by attaching some form of traction to the limb and either fixing this to a weight and utilising the body weight as a counter-extension (sliding extension) or fixing the extension to one end of a splint, the other end of which is firmly pressed against some bony point of the body, producing counter-extension (fixed extension). When angulation is to be combated as well, short lengths of gutter splinting may be applied also.

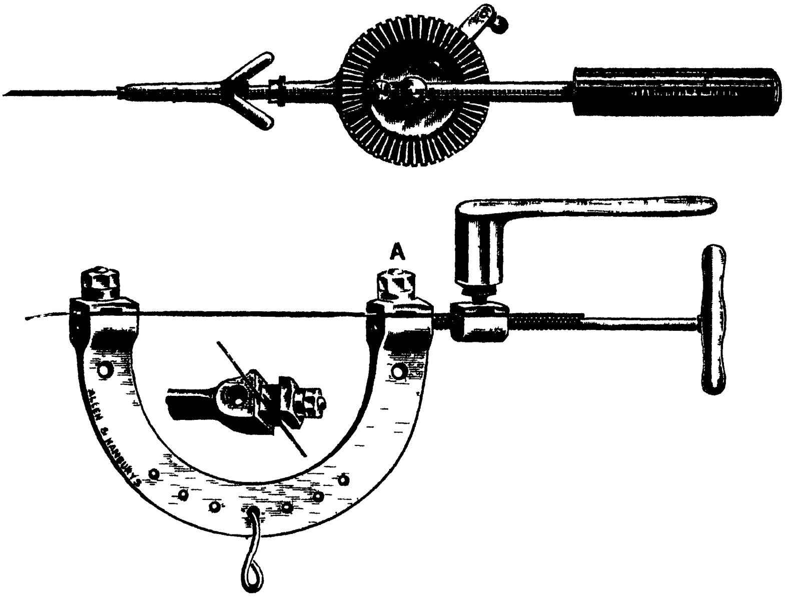


Fig. 215. Kirschner's wire apparatus.

To apply skeleton splints satisfactorily a general anæsthetic should be administered and an efficient pull obtained while the muscles are fully relaxed, while morphia should be given freely for the first forty-eight hours if there is much pain. It is essential to apply enough weight to paralyse the muscles, not merely enough to stimulate them to further contraction ; this weight can often be reduced after a few days.

The following methods of applying extension to the limbs in conjunction with skeleton splints are in common use :—

(*a*) Transfixion pins or wires. (*b*) Adhesive plaster. (*c*) Glue or Unna's paste. (*d*) Sinclair's skate and similar apparatus.

Of these adhesive plaster is still the most commonly used, but Kirschner's wire gives the best results.

(*a*) *Transfixion Pins.* Under this heading are included Kirschner's wires and Steinman's pins, which obtain a very powerful pull, but may produce pressure atrophy of the soft tissues with consequent ulceration, while they are very occasionally followed by infection of the bone, giving rise to consequent necrosis and delayed convalescence. They can be inserted in the condyles of the femur, the tuberosity of the tibia, the malleoli of the ankle, the os calcis or olecranon.

Kirschner's wire is a thin wire which is used as a drill and drilled through the bone. It is then so tightly stretched by a stirrup that it is practically unbendable. By means of this a very heavy extension can be put on, sufficient to pull out and mould into position almost any fracture, but as a special apparatus is needed to keep the wire tense at its insertion it does not give good results except in the hands of an expert.

Steinman's Pins are straight metal pins of various lengths sharpened at one end and shaped at the other to fit into a handle used in their insertion. They can be inserted under nitrous oxide anæsthesia, or when the fracture is "put up," and may be used safely in any cottage hospital, nursing home, or private house, if it is necessary to nurse the case at home.

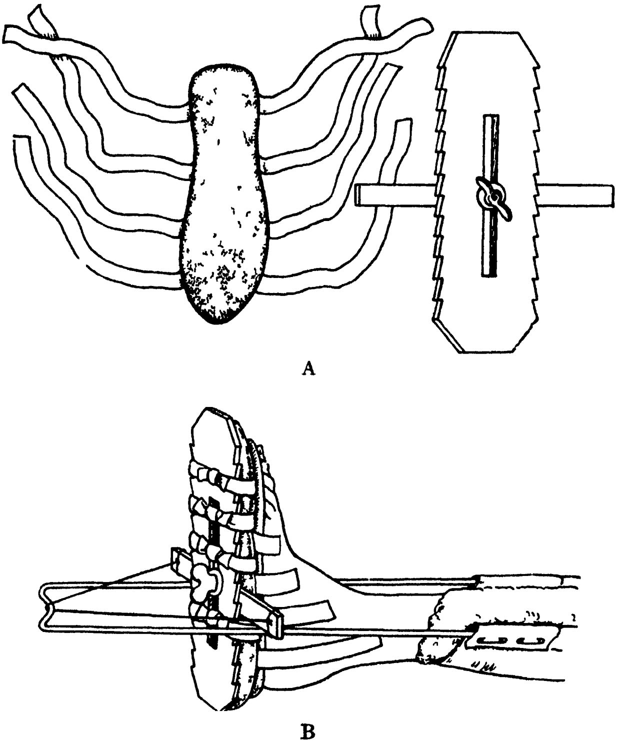


Fig. 216. Sinclair's skate and footpiece. A. Before application. B. After application.

The skin having been shaved and purified, is pulled well up and a small ¼-inch incision made. The pin, fitted in the handle, is then passed down to the bone and forced through with rotatory movements of the wrist—hard work for the surgeon—till the sharp end can be felt under the skin on the opposite side of the limb. This skin is then drawn up and incised for ¼ inch and the pin forced through and tapped into position with a mallet. Strips of gauze wrapped in spirit glue or Whitehead's varnish are now wrapped around the pin ends over the incisions to close these, and a "*stirrup*" applied —the best type being the ice-tong caliper—from the far end of which extension is taken over a pulley by a cord and weight, the limb being supported in a Thomas's splint to which an undercage may be added with advantage to permit of movements of the joints. The weight necessary is much less than with strapping, 10 to 12 pounds usually sufficing for an adult femur, and 5 to

8 pounds for the tibia and fibula. In some cases, as above the os calcis, the Steinman's pin may be passed through the soft tissues immediately above the heelspur. The pins must be retained till an X-ray film shows bony union to be starting, when they can be extracted under gas anæsthesia, and some light extension splint substituted.

(*b*) *Adhesive Plaster*. This preferably should be the zinc oxide variety, as it is less irritating to the skin, the 2-inch width being of most general application. One strip is applied to each side of the limb, if necessary the edges being nicked with scissors to ensure the plaster lying snugly on the curve of the limb. Where it lies over a joint it should be prevented from adhering by cutting a shorter length of plaster and applying this, sticky side to sticky side, over the part it is required to leave free. In the case of the lower limb, nothing should be in contact with the skin lower than a point 3 inches above the malleoli, and the plaster should run well clear of these points and be backed in the manner described above.

The longitudinal strips are maintained in position by several spiral turns around, but never completely encircling the limb, as in this way interference with the circulation and traction on the skin are avoided.

The whole is kept in position by application of a roller bandage, leaving the joints free. The ends of the longitudinal strips are attached to a wooden spreader of such width that, in the case of the leg, the plaster runs clear of the malleoli.

A similar method of applying extension may be made by using flannel bandages only. This is a severe test of bandaging, apt to slip, and not amenable to such a powerful pull.

Neither adhesive plaster nor bandages will hold the heavy weights that a Kirschner's wire will.

(*c*) *Glue*. In this case the limb should not be shaved first. Strips of gauze are utilised for exerting extension and, in the case of the lower extremity, should be 4 inches in width and eight layers thick. The best formula for the glue is as follows:—Alcohol 50 c.c., benzene 25 c.c., Venice turpentine 5 grams, commercial resin 50 grams. This can be applied cold and is painted directly on the skin with a brush. As soon as it has dried sufficiently to become "tacky" the strips of gauze are applied and the whole is bandaged in position. The same precautions and observations as regards the bony points hold good as in the case of strapping.

In cases where the skin is sore or abraded, strips of adhesive plaster or gauze can be incorporated with advantage among the bandages of an Unna's paste dressing (p. 146).

(*d*) *Sinclair's Skate*. When it is impossible to utilise a length of limb for the extension, as in the case of a compound fracture of the tibia, the foot only may be utilised for attachment of the extension, though it is preferable to use a transfixion pin. An ordinary light boot, with tapes between the sole and the upper, may be applied over a sock, or a plaster of Paris boot may be designed on similar lines. Sinclair's skate is a valuable apparatus for the same purpose (Fig. 216). The wooden footpiece padded with thick felt is glued to the foot, and flexion or extension of the ankle joint controlled by the position of the iron cross-bar through which extension is exerted. With the ankle at a right angle it should lie in the same plane as the malleoli.

In the case of the upper extremity a glove with tapes attached to the fingers may be glued to the hand.

Types of Skeleton Splint. Those in common use are Thomas's leg and arm splints (Figs. 217 to 219) and Robert Jones's arm splint. Plaster splints, with multiple windows and strengthened by iron bars, come under this heading.

Thomas's Leg Splint may be taken as the typical example. It was designed to be used as a fixed extension, the padded leather ring taking a counter-extension by firm pressure against the tuber ischii, and the extension being attached to the cross-bar at the end of the splint. This is usually done by means of a piece of blind cord attached to the centre of the spreader, but insomuch as the tension on this requires constant adjustment, an easier method to control it is by means of a buckle and strap, attaching the spreader to the end of the splint. If a gauze and glue extension is in use, the ends are knotted round the end bar of the splint, one strip passing above and one below the side bars of the splint. For ease in adjusting the tension on the extension a Spanish windlass may be incorporated in this. The limb is supported in the splint by a trough formed of a series of slings of flannel bandage attached to the side bars with pins or photographic clips. These also require careful and repeated adjustment. If necessary, small encircling pieces of Gooch's splinting or malleable gutter splints may be applied over the site of the fracture. It is important for efficient extension that the ring should fit firmly against the tuber ischii, and the skin at this point must be attended to carefully, the portion of skin bearing maximum pressure being changed from time to time. To ensure efficient working of the system and make nursing possible, it is necessary to sling the splint from above, so that it swings clear of the bed, and this is best achieved by means of a Balkan beam. This can be contrived at short notice by means of a cross-piece and two uprights by any carpenter. If a beam cannot be obtained. the splint can be slung from a Salter's cradle. or the end supported on a block or specially designed rest attachable to the splint (Fig. 218).

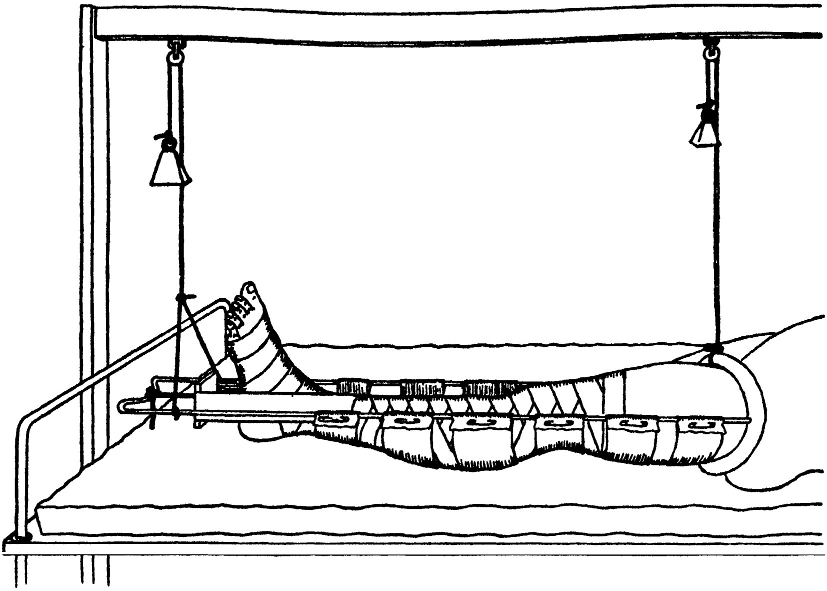


FIG. 217. Thomas's splint in use with "fixed extension." Splint slung clear of the bed with counterpoise weight.

If Thomas's knee splint is to be used in conjunction with a sliding extension by weight and pulley, the splint acts merely as a cradle. The extending force, a variable weight, is attached to the end of the cord coming from the spreader and running over a pulley, and this pulley is attached to the end of the bed or the lower upright of the Balkan beam; the counter-extending force is the body weight, and to bring this into play the foot of the bed must be raised at least 12 inches on wooden blocks. A constant watch must be kept for the patient creeping down the bed, and, if necessary, counter-extension, aided by a roller towel passed round the crutch and the bed head on the opposite side, must be employed to prevent this.

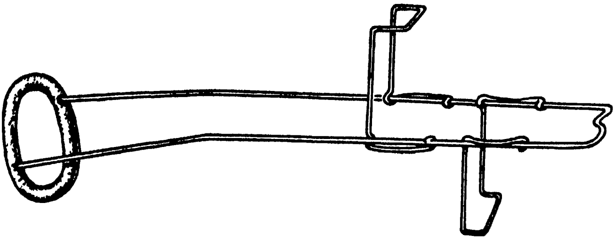


FIG. 218. Thomas's splint, with a detachable footpiece and rest.

Thomas's splint as described above is the standard straight model which maintains the knee and hip in the position of extension. If flexion is required, a Thomas's splint bent to the necessary angle opposite the knee is used, but in this case the extension can act efficiently only if pull is made in the line of the fracture. In this case the extension is attached to the thigh only, the ends of the strips being carried on in the line of the thigh and attached to a weight and pulley acting in this line. The leg is fixed in the splint by a secondary extension. When it is desired to move the knee without disturbing the extension or tampering with the splint, a subcage may be attached (Fig. 219).

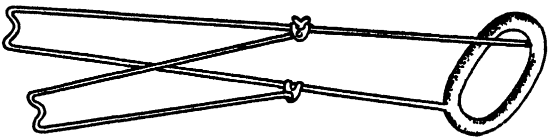


FIG. 219. Thomas's splint with subcage.

It is important to prevent foot drop while the limb lies in the splint, and the foot must be kept elevated with the ankle at right angles. This can be done by a small vertical extension with a weight and pulley attached to the sole of the foot, or by a skeleton foot-piece attachable to the side bars of the splint (Fig. 217). Thomas's splint may be used also as a first aid measure, utilising the principle of fixed extension.

Walking Caliper Splint. This is a modification of Thomas's leg splint, employing the principle of fixed extension and at the same time giving an ambulatory splint (Fig. 331). The body weight is borne direct from the tuber ischii *via* the side bars to the ground. In fitting it, it is essential to see that the ring fits accurately on the tuber, producing a sensation of sitting in the splint, and that the patient's heel is not in contact with the heel of his boot. Where the limbs are of equal length, three-quarters of an inch raising should be applied to the heel of the boot on the sound side. The length of the side bars should be adjustable, and this is most conveniently and accurately done by attaching the two angle irons, which are slotted in the heel of the boot, to the ends of the side bars by a screw thread and locking nut. After two or three days' wear the patient will bed down in the splint, and it will require slight lengthening.

The limb is fixed to the side bars by a leather knee-cap and strap and canvas slings.

Extending Forces. These may be the weight of the limb or a weight attached to the limb, and it is important to remember that by no means all the weight attached is acting directly on the fracture, a good deal being dissipated in friction, especially if external traction by adhesive plaster be employed, though this is considerably less where pins or wires are passed through the bone below the fracture and the weight extension attached thus. Twenty pounds is an average weight for a fractured femur in an adult male, while six to twelve pounds will suffice in the case of children. After some days extension, it is usually possible to reduce the weight to a pound per stone body weight.

3. *Gutter Splints.* These are suitable when the only deformity that is likely to occur is angulation. The best type are those made of aluminium composition padded with felt; they are made in a variety of sizes and have the great merit of being permeable to X-rays. Also they are malleable; they should be carefully moulded to the limb and have an additional padding of soft wool.

Gooch's wooden gutter splints can be used also. Plain wooden splints can be improvised readily in an emergency, but cannot be fitted accurately to a limb.

All splints should be well and evenly padded, and not bandaged too tightly, while it is highly desirable to leave some portion of the limb distal to the splint exposed so that the circulation in the part distal to the injury may be examined from time to time.

When, as is usual, two splints are in use, it is feasible to remove one of them for purposes of massage, while the other remains in position and acts as a support.

Counter-Extending Forces. These may be the body weight, and to make this an efficient counter-extending force, the foot of the bed must be well raised. At least 12 inches of elevation are necessary, and this can be supplemented by a perineal strap passing round the leg to the head of the bed on the opposite side ; a roller towel acts well for this purpose. This device also will produce abduction of the sound limb, which is desirable. When Thomas's splint or its modifications are used with fixed extension, counter-extension is exerted upon some bony process.

If a Hawley table is used, the pull is exerted by a block and tackle or a screw extension attached to the foot, while counter-extension is obtained by a fixed perineal mast pressing on the rami of pubis and ischium. If a fractured femur is being treated by plaster of Paris, once the plaster has set, extension is exerted between the condyles of the femur and malleoli of the ankle below and the pelvic girdle above.

In the case of the upper extremity skeleton splints are applied in a manner exactly similar to that for the leg, but they are not nearly so often required.

Here, for fixed extension, counter-extension is obtained by the pressure of the ring against the chest wall.

Pearson's bed. In all those cases where the leg is immobilised in a skeleton splint, a special bed with a divided mattress is desirable for nursing purposes. Pearson's bed contains all in one the bed, Balkan beam, divided mattress, and device for raising the foot of the bed.

(4) **Strapping.** This is a method of splintage which provides support without rigid fixation, and is suitable for the immediate treatment of minor fractures and sprains, or later after more formal splints have been discarded. It finds its use especially in injuries of the wrist, ankle, hand, and foot; it should not be applied in the presence of extreme swelling; if this is likely to supervene, a pressure pad and bandage should be used for the first forty-eight hours.

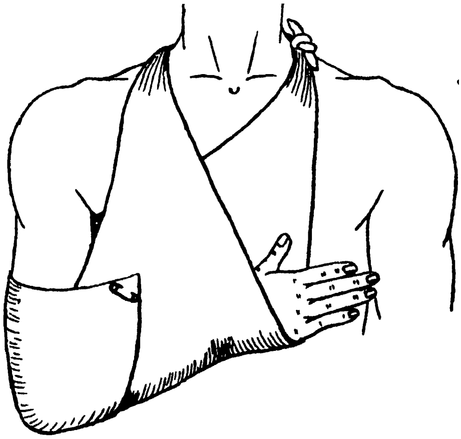


FIG. 220. Sling, showing usual method of application.

The affected part is covered with a layer of stockinette after cleaning and powdering the skin, and loops of adhesive plaster encircling the limb are then applied evenly and firmly from below upwards. It is the standard method of treatment for a fracture of the metatarsus.

(5) **Slings.** These are adjuvants to the fixation or sometimes the sole fixation of fractures of the upper extremity. They are made of linen or calico cut in the shape of a right-angled isosceles triangle, the short sides of which measure 36 inches. They can be cut down as necessary. They are applied as shown (Fig. 220), one tail of the sling starting over the opposite shoulder, with the longest side of the triangle vertical and the apex pointing to the injured side behind the arm. The lower tail is now brought up over the arm and shoulder on the injured side, round the back of the neck, to be knotted there over a pad of wool or felt. The right-angled apex behind the elbow is brought round to the front and pinned there, taking care that the back of the arm is evenly supported. The forearm should be supported by the sling, the hand should lie in it, but not be supported by it, and the tip of the elbow also should hang without support. This ensures the weight of the arm acting as a counter-extending force in injuries proximal to the elbow.

If the angle of flexion at the elbow is to be increased, this is done by taking a reef in the anterior fold of the sling (Fig. 221).

Where it is necessary to support the weight of the arm as in a fracture of the neck of the scapula, a bandage passing over pads of felt as shown (Fig. 226) is applied, and the sling then put on. If it is necessary to produce pronation or supination of the forearm, this is done in the manner shown (Figs. 222 and 223). For pronation, a posterior splint is applied by a bandage passing from the radial to the ulnar side over the front of the limb, and the end attached to the splint and then to the neck of the sling near the opposite shoulder. The maximum effect is obtained with the elbow at an angle of 80 degrees. For supination the bandage is applied from the ulnar to the radial side and the free end fixed to the neck of the sling on the same side. The maximum effect is obtained with the elbow at an angle of 50 degrees. A sling should never be used with the elbow at an angle greater than a right angle. When it is undesirable to have the sling passing over the injured shoulder, it may be applied as shown (Fig. 224), the sling passing down the front of the arm, beneath it, round the chest wall to the back and meeting over the sound shoulder.

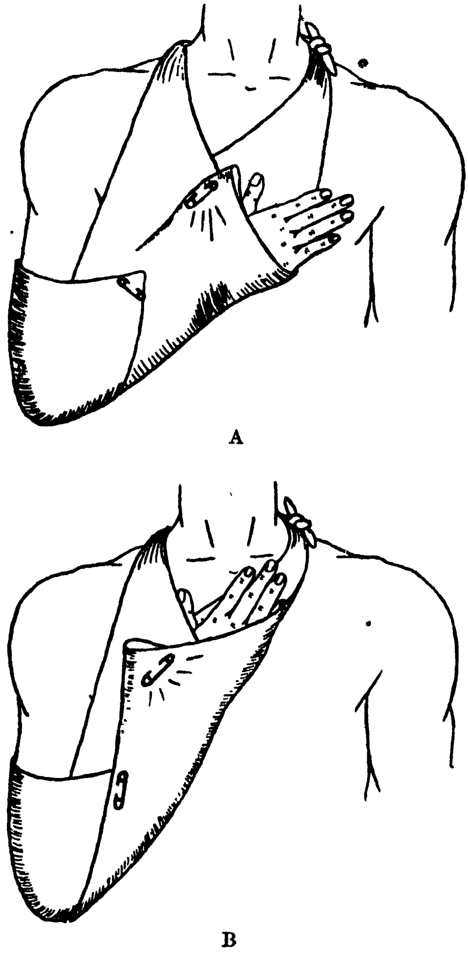


FIG. 221. A. Sling in increased flexion. B. Sling in extreme flexion.

A collar and cuff consists of two loops, one round the neck, the other round the wrist, joined by a length of bandage, the length depending on the amount of flexion of the elbow required.

This is used chiefly as a means of graduated extension of the elbow by slowly increasing day by day the length of the intervening bandage. If at any time the limb will not return to full flexion, it should be rested until full flexion is regained, then gradual extension may be recommenced.

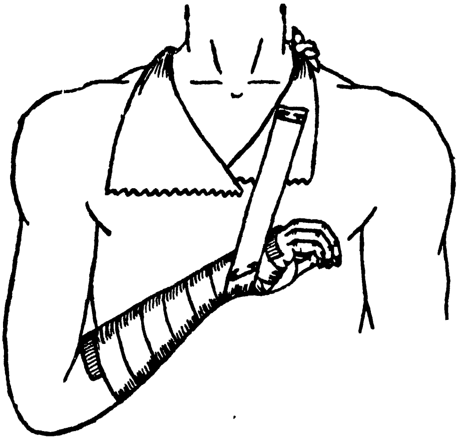


FIG. 222. Device for pronation.

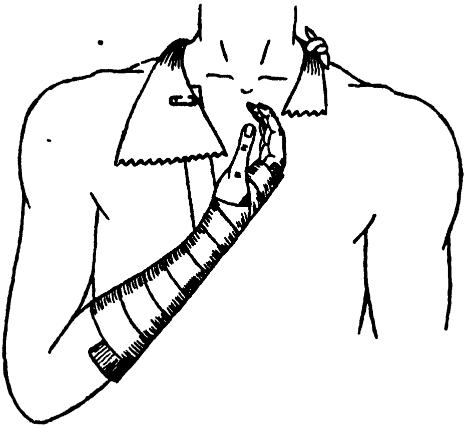


FIG. 223. Device for supination.

(6) **Boots, etc.** These, though not strictly a form of splintage, may be considered here, as they play a large part in the late treatment of certain fractures, and form a means of partial fixation.

When it is desired to throw weight on the outer side of the foot, *i.e.*, to invert the foot, as in many injuries of the inner aspect of the ankle joint, then the inner side of the sole and heel should be raised a third of an inch by placing the wedge between the sole of the foot and the sole of the boot. When it is desired to prevent eversion of the foot, the inner side of the heel is advanced (crocked), and the sole raised on the outer side. When the anterior arch of the foot is injured or dropped, an anterior arch support should be fitted, and these are best made to fit the patient by cutting them out from half-inch sheet cork. In the opinion of the authors, metal plates made from plaster casts are useless, as it is impossible to make plaster casts in the erect attitude, and it is in this position that the feet should be fitted. If there is a tendency to pes cavus with a shortened tendo Achillis, then the arch support is continued backwards under the heel as a platform. Where dorsiflexion of the toes is faulty, the platform device will correct this, or a metatarsal bar applied to the sole of the boot just behind the heads of the metatarsals will allow the normal rocking movement to take place.

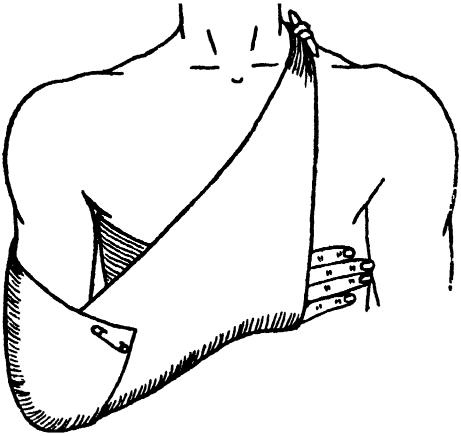


FIG. 224. Sling with both ends over the sound shoulder.

PHYSICAL TREATMENT

There has been a tendency in the past to concentrate upon obtaining perfect anatomical reposition of the fragments, and once this has been attained, to leave the limb rigidly fixed until the fragments unite firmly, forgetting this also will tend to produce firm adhesions among all the scarred and damaged soft tissues around the fracture.

It must never be forgotten that it is of importance to maintain the function of the soft tissues, otherwise convalescence will be delayed unduly and the best result not obtained. At the same time, to attain a perfect result, we must ensure a perfect anatomical result, with *uninterrupted* fixation of the reduced fragments until bony union has occurred, while at the same time securing *active* movements of as many joints as possible of the damaged limb and whole body, provided these can be done without pain.

There is no doubt that in many cases of fracture immediate treatment by massage and mobilisation will secure a perfect result with the greatest rapidity, but this method is fraught with certain pitfalls (such as movement of the fragments out of proper position) and, if not carried out by a specially trained masseur, may and often does end in disaster, so that it is well to bear in mind Böhler's teaching "the use of massage and passive movements in cases of *recent* fractures and of injuries to joints is to-day the commonest cause of bad results and of non-union."

The following are the methods of physical treatment employed :—

1. Active movements. 2. Massage. 3. Passive movements. 4. Electrical treatment. 5. Exercises and weight bearing. 6. Manipulation.

1. *Active Movements.* These are, as might be expected, the most valuable method and should be commenced as soon as they can be performed *painlessly,* while in joints remote from the fracture they should be started at once. Thus in a fracture of the shaft of the humerus the fingers and wrist should be moved freely from the start. Nothing maintains function so well, prevents the wasting of muscle, or, if this has occurred, rebuilds muscle, as active movement. *An ounce of active movement is worth a pound of massage.* The principle may be employed in many ways. Thus a man with a fracture of the femur may save prolonged convalescence by ten minutes' active contraction of his quadriceps twice a day. At a later stage active movements may be performed against resistance, either that of gravity or that supplied by apparatus. For example, the first active movements after a fracture of the neck of the humerus are made in the recumbent position, so that the weight of the arm is not acting, later in the erect attitude, and, finally, in the form of gymnastic exercises. Once active movements are started in any part, passive movements should be abandoned.

Both in active and passive movement it must be emphasised that diminution of range of movement, with increase of pain, swelling and spasm, imply over-treatment, and to continue in the face of these danger signals is to court disaster.

2. *Massage.* This is of great value in reducing reactionary œdema by abolishing stasis, producing local vaso-dilatation and improving vaso-motor tone. It also maintains the nutrition of the muscles, counteracting wasting and preventing adhesions of the soft tissues. Moreover, it is a powerful local sedative and relieves pain, principally by its action in reducing muscular spasm. It may be applied in several ways. For early cases light stroking massage (effleurage) towards the body is best in the region of the fracture, with deeper kneading above and below. After union has occurred the massage may become more vigorous, while where persistent œdema exists deep, firm kneading, even resorting to a mechanical vibrator, should be used.

Massage should be administered in the early stages only if it can be done without disturbing fixation, and this point must be observed rigidly.

3. *Passive Movements.* These prevent stiffness of the joints in the vicinity of a fracture and adhesions of tendons, muscles, and peri-articular tissues ; they should never produce pain or swelling, as this implies that they have been excessive. Such movements maintain muscle balance and sensation, and should always be associated with complete muscular relaxation, which is produced by a short preliminary dose of light massage.

The action of gravity may be utilised, as in gradual extension of the elbow joint, by allowing a forearm to drop slowly while supporting it with the hand.

4. *Electrical Treatment.* The standard application of this method is in the form of faradism to promote muscular contraction, and this can be done while the limb is fixed in a splint ; in the case of a plaster by cutting holes over the motor points. This will maintain contractivity, diminish wasting, prevent adhesions, and improve the local circulation. It achieves its greatest use in a fracture of the femur.

The faradic foot-bath is a very valuable means of dealing with injuries of the foot and ankle. By altering the position of the electrodes and the strength of the current, certain groups of muscles can be picked out or the whole foot exercised equally. Electrical treatment is of use also in reducing persistent œdema.

5. *Exercises and Weight Bearing.* Weight bearing causes union to occur with increased rapidity and improves blood supply and function. In the case of the lower extremity, the adoption as soon as possible of some form of ambulatory splint, such as a caliper or walking plaster, is advantageous. Exercises, such as those on a fixed bicycle or sliding seat, without weight bearing, restore muscle balance and function. Re-education in walking is often necessary and shortens convalescence.

The opportunity may be taken at this point of stating that one of the greatest values of physical treatment is encouragement of a state of optimism in the patient, the will to get on, without which success can never be obtained.

6. *Manipulation.* It is sometimes necessary to complete the full range of movement in a joint by forced movements under gas in order to break down adhesions. Only one definite adhesion should be broken down at one sitting, and the joints should show no evidence of active arthritis at the time, as otherwise a flare-up will result. It is a means of treatment that requires great practical experience and must be undertaken with caution.

OPERATIVE TREATMENT OF FRACTURES

Indications. (1) If other methods of reduction have failed and perfect anatomical position is considered essential. This varies considerably with the fracture under consideration, for a fracture of the shaft of the humerus will give a perfect functional result with bad anatomical position, while in the case of the femur perfect anatomical position is essential. Perfect anatomical reposition is also essential in the case of fractures near or into a joint.

(2) The presence of complications such as injuries to great vessels, nerves, etc. (see pp. 255 and 327).

(3) Certain specific fractures to be mentioned in detail later, of the type in which bony processes for the attachment of muscles are avulsed.

(4) Certain cases of comminuted or malunited fracture.

General Considerations. Operative measures are to be considered in the light of a trump card to be held in reserve. They may prove extremely difficult and impose a rigid test of faultless technique; they are very rarely necessary in children, and in their case every effort should be made to avoid operation. The most rigid aseptic technique should be followed, the skin being cleaned thoroughly some time before operation and again on the operating table, and, if bruised or unhealthy, operation postponed till this is remedied. The presence of a gross septic focus elsewhere in the body is a definite contra-indication. After incision of the skin the edges should be clipped off with sterile towels and a fresh knife used.

The aim is to obtain firm though not absolutely rigid fixation, to disturb the fractured ends as little as possible, and, for preference, to leave no unabsorbable foreign body in the wound, while the periosteum should be interfered with as little as possible, as this will delay union. Very rigid fixation is not desirable, as it produces the same result. A moderate amount of play between the bone ends produces mild irritation and expedites union. The optimum time for operation is the third to the fifth day, as collapse has then been recovered from and the reparative processes of the body established. Therefore, if sepsis should be introduced, the patient is in the best possible condition to combat it. After this time the healing process tends to obscure landmarks and render operation increasingly more difficult. As the more complete the muscular relaxation, the easier the operation, in the case of the lower extremity spinal anæsthesia will be found helpful. After the operation the case must be treated on exactly similar lines to a case not submitted to operation, and internal fixation not be regarded as any excuse for neglecting external fixation.

Methods of Fixation. (1) Simple impaction. (2) Suture. (3) Grafting. (4) Wiring. (5) Pegs. (6) Plating.

1. *Simple Impaction.* This is the ideal method, as nothing is left in the wound, and there is relatively little disturbance. It is applicable to many purely transverse fractures, particularly those of the forearm, as the series of interdigitating spikes on the two fragments can be fitted together with extreme accuracy and give valuable aid in checking relative rotation of the two fragments. If operation is unduly delayed impaction becomes more difficult and less firm, because of the commencing formation of callus. Initial distraction of the fragments is obtained by sharp hooks or long elevators. This is the method always to be adopted if possible.

2. *Suture.* This is done for preference with absorbable tissue such as catgut or kangaroo tendon. In the case of the olecranon or patella the torn aponeurosis only need be sutured or a circular suture passed right round the bone. If holes are bored through a bone for purposes of suture, catgut tends to break and wire will have to be used. In spiral fractures catgut can be used as a lashing round the fragments.

3. *Grafting.* Autogenous grafts should be used; they should be fixed firmly between the bone ends, and they should retain a covering of periosteum. A variety of mechanical methods are in use. Those commonly used are the step-cut graft, in which the two ends interlock and are held by a mattress suture, the inlay graft, in which a trough is cut and the graft packed in, and the intramedullary peg. These grafts are best cut out with an Albee electric saw which is kept cool by a stream of saline. Retention of the periosteum enables early vascularisation of the graft to occur.

4. *Wiring.* In this method wire is passed around or through holes in the bone, silver wire or, better, Viennese twist, *i.e.*, piano wire, being used. The ends are twisted or knotted, cut short, and the sharp points beaten into the bone and covered with soft tissue. This is not a very satisfactory method.

5. *Pegs.* Boiled beef bone pegs cut slightly conical towards the ends, with a mark at the centre, are the best. They are used principally as intramedullary pegs, being jammed into one fragment and then fed into the medullary cavity of the other until the centre of the peg is opposite the line of fracture. Their disadvantage is that they are liable to break, they require much disturbance for insertion, destroy medullary tissue, and therefore abolish internal callus, and take a very long time to absorb. They may be used also for pegging on a bony process such as a condyle of the femur, or the back part of the os calcis. Iron nails or screws are used occasionally for this purpose.

6. *Plating.* The usual type of plates are those introduced by Lane, but they are seldom used at present. They are made in a series of sizes and shapes suitable for any fracture, and are applied with an elaborate series of instruments specially designed by Lane for the purpose. They leave a permanent foreign body in the wound, which may give rise to further trouble at a later date, and should sepsis supervene prove very troublesome. In the early stages they produce very rigid fixation, delaying union, and later, owing to rarefaction round the screws, they work loose at just that period when in a case not subjected to operation union would be becoming firm. Unless this fact is appreciated disaster will result, as external fixation must be retained longer than usual. They involve considerable manipulation in application, and should be used only in situations where they can be well covered by muscle. A satisfactory plate is made of boiled beef bone, which is fixed with bone nails or screws. This gives firm enough fixation and is slowly absorbed.

COMPOUND (OPEN) FRACTURES

In this variety of fracture there is a break of continuity of the skin or mucous membrane, and a connection of the deeper parts of the wound and the bone ends with the external surface, thus these are often spoken of as **open fractures**; a fracture may be rendered compound from without or from within (see p. 405). This introduces the grave risk of infection both of the soft tissues and the bone, with a train of serious results. As an immediate result there may be fulminating infection of the wound and septic gangrene, or if gas-producing organisms are present, gas gangrene results. If the infection is less acute a localised abscess will form, and the ends of the bone become infected so that necrosis results. This involves the sequence of septic osteitis with new bone formation, the extrusion or removal of sequestra, and great delay in union, or more likely non-union from sclerosis of the bone ends. Beside the local effects there are the dangers of septicæmia and pyæmia.

Should septic osteitis occur in connection with a compound fracture, its general pathology and symptomatology are very similar to that of acute septic osteitis in general, but it must be remembered that both the general reaction and toxæmia and the local necrosis in the bone are usually much less severe than in cases of acute septic osteitis of hæmatogenous origin. Necrosis in a compound fracture will involve both any loose fragments of bone which may be present and the ends of the bone shaft, so that the sequestra may be very slow in loosening, and there may be much loss of bone. The presence of sepsis stimulates the formation of new bone and an excessive amount of callus is frequently formed, though it may be of a feeble and crumbling nature.

If as the result of treatment asepsis is maintained, by the infection which is almost certainly present being combated and abolished, then union and repair will progress in an exactly similar manner as in a simple fracture (see p. 412), though it often happens that it takes a little longer, perhaps owing to the fact that the violence was probably more severe. Should infection occur and asepsis fail, union and repair will be greatly delayed, and it is quite likely that neither union nor healing of the wound in the soft tissues will occur until all sequestra are removed. The first essential in treatment, therefore, is to preserve asepsis.

Treatment. A compound or open fracture must be considered as a surgical emergency of the most serious nature, and must be dealt with at once. If twelve hours are allowed to pass and nothing is done, then it is too late for any hope of influencing the onset of infection.

In the *direct type* of open fracture (see p. 405) the skin and soft tissues in sequence right down to the bone are destroyed by the violence of the injury, and organisms can be carried, therefore, straight in from the outside, so that the whole wound is potentially infected.

In the *indirect type* of open fracture the skin is perforated by the sharp fractured ends, and the deeper parts of the wound are sterile, therefore in this latter type no attempt at reduction should be made until the wound has been excised as cleanly as possible, all dead and devitalised tissue being removed ; the fracture may then be reduced. In the former type the wound is also, if possible, excised completely, and all dead tissue, including loose fragments of bone, removed. Naturally the skin must be purified before wound excision, but the less antiseptic lotions are used the better. The limb should be shaved and then painted with a spirit solution of some antiseptic such as iodine. The wound is then excised, this being the only method of combating infection with certainty. If the injury is more than twelve hours old it is useless to excise the wound and it must be left freely open and lightly packed, and for these open wounds the Carrel Dakin method of treatment yields good results. Complete excision is obviously not always possible if important structures are involved. The resulting wound should be closed only if there is a reasonable chance that infection will not supervene, and in any case it should be sutured loosely and all stitches removed on the slightest indication of infection. In this way extensive necrosis of bone, to say the

Methods of Fixation. (1) Simple impaction. (2) Suture. (3) Grafting. (4) Wiring. (5) Pegs. (6) Plating.

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6. *Plating.* The usual type of plates are those introduced by Lane, but they are seldom used at present. They are made in a series of sizes and shapes suitable for any fracture, and are applied with an elaborate series of instruments specially designed by Lane for the purpose. They leave a permanent foreign body in the wound, which may give rise to further trouble at a later date, and should sepsis supervene prove very troublesome. In the early stages they produce very rigid fixation, delaying union, and later, owing to rarefaction round the screws, they work loose at just that period when in a case not subjected to operation union would be becoming firm. Unless this fact is appreciated disaster will result, as external fixation must be retained longer than usual. They involve considerable manipulation in application, and should be used only in situations where they can be well covered by muscle. A satisfactory plate is made of boiled beef bone, which is fixed with bone nails or screws. This gives firm enough fixation and is slowly absorbed.

COMPOUND (OPEN) FRACTURES

In this variety of fracture there is a break of continuity of the skin or mucous membrane, and a connection of the deeper parts of the wound and the bone ends with the external surface, thus these are often spoken of as **open fractures**; a fracture may be rendered compound from without or from within (see p. 405). This introduces the grave risk of infection both of the soft tissues and the bone, with a train of serious results. As an immediate result there may be fulminating infection of the wound and septic gangrene, or if gas-producing organisms are present, gas gangrene results. If the infection is less acute a localised abscess will form, and the ends of the bone become infected so that necrosis results. This involves the sequence of septic osteitis with new bone formation, the extrusion or removal of sequestra, and great delay in union, or more likely non-union from sclerosis of the bone ends. Beside the local effects there are the dangers of septicæmia and pyæmia.

Should septic osteitis occur in connection with a compound fracture, its general pathology and symptomatology are very similar to that of acute septic osteitis in general, but it must be remembered that both the general reaction and toxæmia and the local necrosis in the bone are usually much less severe than in cases of acute septic osteitis of hæmatogenous origin. Necrosis in a compound fracture will involve both any loose fragments of bone which may be present and the ends of the bone shaft, so that the sequestra may be very slow in loosening, and there may be much loss of bone. The presence of sepsis stimulates the formation of new bone and an excessive amount of callus is frequently formed, though it may be of a feeble and crumbling nature.

If as the result of treatment asepsis is maintained, by the infection which is almost certainly present being combated and abolished, then union and repair will progress in an exactly similar manner as in a simple fracture (see p. 412), though it often happens that it takes a little longer, perhaps owing to the fact that the violence was probably more severe. Should infection occur and asepsis fail, union and repair will be greatly delayed, and it is quite likely that neither union nor healing of the wound in the soft tissues will occur until all sequestra are removed. The first essential in treatment, therefore, is to preserve asepsis.

Treatment. A compound or open fracture must be considered as a surgical emergency of the most serious nature, and must be dealt with at once. If twelve hours are allowed to pass and nothing is done, then it is too late for any hope of influencing the onset of infection.

In the *direct type* of open fracture (see p. 405) the skin and soft tissues in sequence right down to the bone are destroyed by the violence of the injury, and organisms can be carried, therefore, straight in from the outside, so that the whole wound is potentially infected.

In the *indirect type* of open fracture the skin is perforated by the sharp fractured ends, and the deeper parts of the wound are sterile, therefore in this latter type no attempt at reduction should be made until the wound has been excised as cleanly as possible, all dead and devitalised tissue being removed ; the fracture may then be reduced. In the former type the wound is also, if possible, excised completely, and all dead tissue, including loose fragments of bone, removed. Naturally the skin must be purified before wound excision, but the less antiseptic lotions are used the better. The limb should be shaved and then painted with a spirit solution of some antiseptic such as iodine. The wound is then excised, this being the only method of combating infection with certainty. If the injury is more than twelve hours old it is useless to excise the wound and it must be left freely open and lightly packed, and for these open wounds the Carrel Dakin method of treatment yields good results. Complete excision is obviously not always possible if important structures are involved. The resulting wound should be closed only if there is a reasonable chance that infection will not supervene, and in any case it should be sutured loosely and all stitches removed on the slightest indication of infection. In this way extensive necrosis of bone, to say the least, will be avoided. If there are doubts as to the sterility of the wound it is better to treat it as an open wound, packing it lightly with gauze soaked in some antiseptic, eusol being very suitable for this purpose; lately sulphanilamide has been packed into the wound, with marked success both as regards asepsis and union. The part that antiseptics can be expected to play in the purification of the wound is limited. It is absolutely unjustifiable to insert any form of internal fixation at the time of the primary operation, for it leads to a greatly increased risk of sepsis and necrosis. Splintage is carried out as outlined under simple fractures, but pin transfixion and skeleton splints giving free access for dressing are clearly indicated. The after-treatment of the wound consists in removal of the stitches on the eighth day provided no infection supervenes, and the case thereafter is treated in the same way as a simple fracture. If an open or partially closed wound remains sterile, if practicable, secondary suture may be carried out.

For further treatment of compound fractures due to gunshot wounds, see Appendix.

Complications.

(1) **Infection by Pyogenic Organisms** (usually Streptococcus pyogenes or Staphylococcus aureus or albus). This will manifest itself by the end of twenty-four hours or forty-eight hours, and is usually ushered in by a rigor. There is a sense of tension in the wound, the edges of which look puffy and glazed, while the temperature is high and there is severe constitutional disturbance. The whole wound should be opened up freely and packed lightly with antiseptic. Incisions should be made only if there is evidence of definite localisation of the infection with abscess formation. Sulphanilamide should be given by the mouth; polyvalent antistreptococcic serum may be tried, but is usually disappointing.

(2) **Infection by Anaerobic Organisms.** This, although fortunately not common in civil practice, must never be lost sight of, nor must the fact that if we wait for palpable gas in the tissues before diagnosing the condition, we cannot hope to save the life of many patients. It is usually met with in road injuries and accidents where street dirt has entered the wound. The early symptoms and signs are general rather than local. There is profound collapse associated with a peculiar mental alertness, while the pulse is almost uncountable and the patient sweating and anxious. Locally the wound swells and sometimes shows a brownish pigmentation. It has an earthy odour and bubbles of gas may be seen in it, while later gas may be palpable under the skin as surgical emphysema. The treatment must be radical. The wound should be opened freely, and any infected muscle groups removed. If, however, the wound is extensive, or the general reaction marked, it is wiser to adopt immediate amputation while this will save life and not delay till too late. A guillotine amputation should *never* be performed; flaps, consisting of skin only, are cut, and are turned back and left open. There has been placed on the market recently a reliable mixed antiserum for anaerobic organisms, and this should be given at once as a routine in all severe compound fractures; sulphanilamide must also be given.

(3) **Tetanus.** This should never arise, as all wounds in which contamination with earth or dust is suspected should be treated by giving a prophylactic dose of antitetanic serum, 500 USA units, at once. This confers immunity lasting about seven days, and therefore it may need to be repeated (see p. 88).

(4) **Direct Traumatic Gangrene.** If gross destruction of tissue has occurred with impairment of the blood supply, gangrene may supervene in the absence of infection. Amputation is necessary (see p. 160).

(5) **Secondary Hæmorrhage.** This may supervene at any time if the wound has become infected and must be dealt with locally if possible, but may necessitate amputation (see p. 51).

(6) **Infection of Bone.** If the wound is kept freely open this should result only in local necrosis. The resulting sequestra may take a long time to separate, the time depending on the size of the bone, and varying from three weeks to three months. X-ray films are of value to show when sequestra are separated and suitable for surgical removal. Occasionally a sequestrum is discharged spontaneously (see p. 537).

(7) **Infection of Joints.** This may result either from the original injury entering the joint or by spread of infection through the capsule. If there is a joint in the vicinity of a fracture, simple or compound, a sympathetic serous effusion is always present. If definite suppurative arthritis develops, it must be treated on the usual lines, and may make the deciding factor for amputation (see p. 444).

(8) **Splint Sores.** While these may occur with simple fractures they are more often seen in association with compound varieties. They should be guarded against carefully by rigid attention to the skin in any situation that is liable to be subjected to prolonged and unusual pressure, the skin being kept clean, hardened with spirit, and kept dry with dusting powder. If possible the portion of skin bearing pressure should be altered from time to time. In the case of the upper extremity sores are not often seen, but in the lower extremity they are common, particularly where the ring of a Thomas's splint presses on the tuber ischii, and this may necessitate changing from a Thomas's to a Hodgen's splint. They also occur at the back of the heel, and this may be controlled by suspending the foot with a counter-weight (Fig. 244) or placing a padded ring under the heel. Sores may occur at any point from the over-zealous application of adhesive strapping or plaster of Paris. Once they have formed they should be treated with a 2 per cent. tannic acid dressing. If sloughing is occurring they are best kept dry till the slough has separated.

Remote Results. In the case of a compound fracture the parts must be kept rigidly at rest in the early stages, otherwise infection will be disseminated, and it follows, therefore, that function is totally in abeyance for some time and much trouble ensues therefrom. Muscles waste, become adherent to surrounding structures, and in parts replaced by fibrous tissues. They also become shortened from paralysis of antagonistic groups and faulty treatment in not maintaining joints in the neutral position. Joints become fixed by intra-articular or, more commonly, periarticular adhesions, and they should always be treated, therefore, in that position which is best should ankylosis supervene. As soon as infection is quiescent, physical treatment should be inaugurated on the usual lines, but special care should be taken to watch for any flare-up of the infective process. This applies to all surgical manipulations upon compound fractures, as they will have disastrous results if practised while infection is still active.

Amputation in Compound Fractures. The question of amputation will have to be considered in many of the more severe types of compound fractures, especially those which are due to severe crushing or mangling. It is impossible to lay down general rules for guidance in this matter, and, although certain general principles may be enumerated, it is wise to get the advice of an experienced general surgeon in these cases.

(1) It is justifiable to run a risk to save a limb in a young person which would not be justified in an older patient, and to save an arm when it would not be permissible in attempting to save a leg.

(2) Severe crushing or comminution of the bones, the opening of joints, destruction of main vessels and nerves, gross laceration of soft tissues, and extensive destruction of the skin are all features which individually are not conclusive, but which when several of them are present together point in general towards amputation.

(3) The surgeon should ask himself whether, even if the limb is saved and heals, it will be more useful than an artificial limb.

Many patients with severe compound fractures are in a profound condition of collapse, and it is a vexed question whether, if an amputation is necessary, it should be performed at once, or after an interval to allow the patient to rally from his collapse, and during which he is kept warm, given fluids and morphia and treated for collapse generally. The latter proceeding would undoubtedly be the best were it not for the fact that the presence of the mangled limb in many cases appears to intensify the shock and prolong the collapse, so that the patient does not rally until the limb is removed. Each case must be judged upon its merits. At a later date it may become obvious that attempts to save the limb have failed, and amputation may then become necessary because of gangrene, spreading infection and suppuration or secondary hæmorrhage.

CHAPTER XV

GENERAL CONSIDERATIONS WITH REGARD TO INJURIES OF JOINTS

Surgical Anatomy. The joints of the body vary considerably in their structure, strength and movements. For a full description of the various types of joints the reader is referred to the standard text-books on anatomy, but it must be remembered that in general the articular surfaces are covered by a thin layer of cartilage and that they and the portions of the bones which enter into the joint are enclosed within a thick fibrous capsule, which is lined by the synovial membrane and is continuous with the periosteum of the bone. This synovial membrane covers the whole of the inner surface of the capsule and is then reflected on to the bone as far as the commencement of the articular cartilage, covers any intra-articular ligaments there may be, and often projects into the joint in the form of free folds. This membrane secretes into the joint cavity an oily fluid known as synovia, which contains mucin. In a normal joint very little of this fluid is present and the joint cavity must be regarded more or less as a potential space; but as the result of various injuries and diseases of the joint, synovia will be poured out in excess, causing the capsule to become distended while the patient usually automatically places the joint in the position of greatest comfort, which is generally one of slight flexion. If this distension with fluid persists for some time or recurs often, the capsule becomes permanently distended, the ligaments stretched and the joint weak and infirm.

As the result of certain diseased processes and continual irritation, it is not unusual to find in the ligaments and synovial membranes foci of cartilage appearing, usually hyaline in type, and these in time even may undergo ossification.

The blood supply of certain portions of the joints is particularly free, the bone ends and the synovial membrane being vascular, but it must be remembered that the articular cartilage and some of the ligaments, especially intra-articular ones, are very avascular and have very little blood supply at all; they derive their nutrition from the synovial fluid. The nerve supply of a joint is usually derived from the nerves supplying the muscles around it, and this, by means of trophic influence, may account for the rapid wasting seen in the muscles controlling a joint when the joint is diseased or injured.

The strength and stability of a joint depend upon different features connected with it. In all joints the air pressure and the effect of suction between the bone surfaces tend to keep them in position to a certain extent, as is well seen in the case of the hip. The shape of the bone ends may contribute greatly to the strength, as in the case where the end of one bone fits into a socket in the other bone; this is well exemplified in the elbow, hip and ankle joints. The ligaments and capsule of a joint are sometimes a great source of strength, as is illustrated in the case of the knee and the carpal and tarsal joints, while finally the muscles, tendons and other structures which surround the joint will, in some cases, be its main source of strength; the shoulder is the best example of this.

It must be remembered that though many injuries of joints are primary injuries in the sense that only structures immediately connected with the joint are involved, nevertheless it is not unusual for a joint to become secondarily involved in fractures of the bones near by, from which cracks or fissures may radiate down and involve the joint surfaces.

A joint may be injured either by violence applied directly over the joint itself, in which case a contusion or penetrating wound is the usual result, or by violence applied by torsion or leverage from a distance, in which case a sprain or dislocation tends to occur.

The possible injuries to a joint may be classified as follows :—

1. Sprains and sprain-fractures.
2. Contusions.
3. Internal derangements.
4. Dislocations and subluxations.
5. Penetrating wounds.

General Immediate Results of an Injury. These vary in detail according to the particular structure upon which the brunt of the injury falls, but their broad outlines are the same in all such injuries.

The synovial membrane becomes hyperæmic, œdematous, thickened and infiltrated with leucocytes, while it tends to encroach over the edges of the articular cartilage in the form of a veil. Consequent on this an effusion rich in fibrin is poured out into the joint. If the injury is at all severe this will be mixed with blood, constituting a hæmarthrosis. This forms an admirable seed bed for any infection which may reach it, in which case an empyema of the joint or pyoarthrosis results. Synovial exudation or the fluid poured out in a pure traumatic synovitis tends to absorb, but is sometimes unduly persistent or recurs on slight provocation, especially if the limb is kept immobilised in a splint.

The ligaments are softened, œdematous, and stretch if strain is allowed to come upon them. If they are actually torn, healing occurs by fibrosis, which leaves a weakened structure: great care must be taken to prevent overstretching in the early stages of repair, otherwise a permanently unstable joint will result. Ligaments tend to tear away at their site of attachment to the bones, producing a sprain-fracture. The periosteum is torn and an output of bony tissue, sometimes excessive, results. This type of injury is peculiarly painful, slow in healing, and liable to be followed by Myositis Ossificans Traumatica (Chapter XIII., p. 388).

The capsule may be stretched or torn, including the attachment to it and around it of muscles and tendons. In the repair of these injuries peri-articular and intra-articular adhesions limiting the function of the joint tend to occur (see Ankylosis, Chapter XIX., p. 589).

The articular cartilage may be damaged or destroyed either by the violence of the injury or by the marginal growth over it of inflamed synovial membrane. Before any healing can occur in it, it must become vascularised, and it then heals by fibrosis. If opposing joint surfaces are damaged dense fibrous adhesions, producing fibrous ankylosis, may result. Occasionally gross pieces of cartilage and underlying bone become detached, forming pedunculated or free traumatic loose bodies. Where plates of fibro-cartilage exist in the joint, these also may be detached as loose bodies.

Late Results. The ideal result is complete resolution to a normal joint, and in cases treated properly, especially in young subjects, this usually occurs, but should infection succeed in reaching the joint, either by the blood stream or by direct penetration, acute suppurative arthritis results. In this case the inflammation, thickening and softening of the ligaments and synovial membrane are much greater and the articular cartilage tends to total destruction from ingrowth of the pannus of granulating synovial membrane, from autolysis by the toxins in the joint and, once the underlying bone is exposed, by stripping off in flakes. Portions of the bone may die and form sequestra usually, whilst new bone is thrown out in other places. The pus in the joint bursts through the capsule and spreads in the connective tissue planes. Finally pathological dislocation may result. In this case healing produces dense fibrous or bony ankylosis, with possibly sinuses leading down to pockets of infected bone.

In the absence of infection, if any irregularity results in the articular surfaces, or a loose body is left, particularly in those of advancing years, troublesome traumatic osteoarthritis is prone to occur. If ligaments have become stretched, then permanent weakness, with attacks of recurring synovial effusion, are to be expected, and if a loose body is present periodical attacks of locking followed by effusion (see p. 513).

Lastly, it must be remembered that a purely traumatic lesion may pave the way for more permanent and serious disease, such as tuberculosis.

Treatment (of joint injuries in general and sprains and sprain-fractures in particular). An X-ray photograph should be taken as a routine, and the treatment consists in putting the joint at rest in the position of ease, that is to say, that which not only confers comfort by relaxing the damaged ligament, but, should the joint become ankylosed, gives a good functional result; and maintaining it at rest by suitable fixation, *i.e.*, by firm bandages; splints are better avoided. The onset of effusion may be combated if possible by applying a pressure bandage, the joint being powdered, covered with a layer of wool, and a roller bandage evenly applied. A thin layer of wool is applied over this, then a layer of bandage, then wool, then bandage, with increasing tightness until a firm support is obtained; careful watch must be kept in these cases to see that the circulation is not interfered with. Once the tendency to effusion has passed support may be given by strapping applied over stockinette. When there is a definite point of tearing of ligamentous attachment a pad of folded sticking plaster may be incorporated. Once effusion has occurred its absorption is promoted by the maintenance of a firm bandage and the application of a Scott's dressing or counter-irritants,while after two or three days contrast bathing with hot and cold water, massage and diathermy are all helpful. Electrical treatment and massage may be given to prevent muscular wasting and improve the blood supply, but care must be taken in the early stages not to overstretch damaged tissues or cause pain. These are also of assistance in removing persistent œdema and effusion. Extreme degrees of effusion will require aspiration, which must be carried out under the most rigid aseptic precautions, and be repeated if necessary, and the cytology and bacteriology of the fluid should be studied. In persistent effusion the possibility of a toxic synovitis from dental infection, rheumatism, tuberculosis, gonorrhœa, etc., should be considered, but many cases are due to lack of use and poor blood supply preventing the reabsorption of the exudate and in these cases massage and active movements effect a rapid cure. Once effusion is subsiding, passive leading on to active movements may be commenced, being controlled by the production of any pain or spasm. This will be on an average from five to ten days. If a particular structure has been injured steps must be taken to protect it; thus in a sprain of the external lateral ligament of the ankle joint the outer side of the sole of the boot should be raised. If extreme tenderness and pain persist over the site of insertion of a ligament this may be treated by blistering or the insertion of a hot needle, while if bony or cartilaginous fragments have been detached, forming loose bodies, these will require surgical removal.

Lastly, adhesions may form which will require breaking down under anæsthesia, but this is a form of treatment not to be undertaken lightly.

If adhesions are suitable for breaking down, there is limitation of movement in one particular direction, part of the normal range being practicable, but being brought up with a jerk. Dense adhesions, such as are formed by serious arthritis, do not improve with wrenching, as they only reform and become even denser than previously. Once inflammation has subsided, the sooner adhesions are tackled the better, while they are still soft and pliant. The manipulations should be carried out by steady pressure, and once one definite adhesion has been felt to give way, not persisted in any further that day. A second manipulation must be carried out later if necessary. After manipulation there is sure to be reactionary effusion, so that the joint should be kept at rest for two or three days. Manipulation should *never* be undertaken in the presence of active inflammation, or disaster may result. If much force is likely to be necessary, the bones above and below should be protected by splints, as usually they are atrophic and may fracture more readily than the adhesions it is required to break down. If ankylosis cannot be corrected by manipulation and the position is bad or a mobile joint a necessity, then excision or arthroplasty may have to be resorted to.

(1) **Sprains.** A sprain is the result of violent movement of a joint which forces it too far in a particular direction, with the result that one or more of its ligaments are stretched or torn; the synovial membrane is also usually damaged, so that an effusion of synovia and blood occurs into the joint. Muscles and tendons around may be stretched and torn, while in some cases small portions of bone are torn off at the site of the attachment of strong ligaments (*sprain-fracture*). Sprains are most commonly seen in connection with the ankle, wrist, knee and shoulder.

Clinically such an injury occurs after moderate violence and is accompanied by an intense sickening pain, and often by a feeling or sound of some tissue cracking or tearing. Movements of the joint are painful, while there is special pain on stretching or pressure upon the particular ligament damaged; effusion into the joint is present, and there will also be marked swelling around the ligament concerned, which after a few hours will give rise to bruising of the skin and effusion of blood for some inches round. In this way it is usually possible to diagnose which ligaments are damaged, while in a sprain of this kind the pain and spot most tender to pressure lie over a ligament, whereas in the case of a fracture they lie over a bone. It must be remembered also that in a sprain there is no alteration of the relation of the bony points to each other, and no deformity as in the case of a fracture or dislocation. *In every case it is essential to have an X-ray picture.*

The *treatment* of sprains is conducted on the general principles enunciated above; in addition, it is of great importance to provide the damaged ligament with some support to ensure that it cannot possibly be stretched again until it is firmly healed. In a very few cases a splint will be necessary, but in most instances the joint should be strapped firmly in such a position that the injured ligament cannot be stretched and the patient encouraged to use the joint gently. This support is of equally great importance either in acute and recent sprains or in chronic neglected ones. Inefficient treatment or neglect of a sprain will lead to great and lasting disability. Massage and active movements should be initiated within forty-eight hours, keeping the joint strapped, and will very materially hasten the absorption of the periarticular and synovial effusions and permit of a considerably shortened convalescence. The strapping seldom needs to be retained for more than ten days to a fortnight, but especially in the case of the ankle weight must not be taken for at least three weeks, the injured ligaments being supported by the raising of the sole or heel of the boot and the use of a stick on walking.

(2) **Contusions of Joints.** These injuries are due to the joint surfaces being violently driven against each other as the result of either direct or indirect violence, especially that associated with falls on the hands or the feet. The joint surfaces and synovial membranes are bruised or torn, and there results an effusion into the joint cavity of either pure synovia, blood-stained synovia, or practically pure blood (hæmarthrosis). The tissues around the joint also will be bruised and torn. The joints most often affected are the shoulder and hip.

Clinically there is great pain on moving the joint, and swelling and discoloration soon appear, while the joint is held in a flexed position; a persistent effusion sometimes will follow this condition, while firm intra-articular adhesions are generally the result.

The treatment is that described above.

(3) **Internal Derangements.** These are seen most commonly in those joints in which portions of fibro-cartilage are interposed between the joint surfaces, though loose bodies may occur in any joint. They are therefore seen particularly in the knee and temporo-mandibular joint. The cartilage, once torn, forms a pedunculated or completely free, loose body, which slips in and out between the articulating surfaces, producing locking and subsequent effusion. Usually reduction can be effected by suitable manipulation, often with a characteristic click, but if derangement is repeated open operation and removal of the cartilage should be resorted to. If the cartilage is allowed to remain it produces chronic arthritic changes in the joint (see p. 438).

(4) **Dislocations.** A dislocation is a persistent displacement or separation of the bony surfaces which enter into and form a joint In the majority of instances this occurs as the result of injury (traumatic), but other instances are due to disease (pathological). Congenital dislocations are also seen; these are described on pp. 675, 683 and 706.

Traumatic dislocations most commonly occur as the result of indirect violence, and in those joints which owe their stability to surrounding muscles rather than to ligaments or to bony interlocking of their surfaces; this explains the fact that the shoulder is the commonest joint in which dislocation occurs, for once the muscles guarding the joint are caught unawares then dislocation is easy. Dislocations due to direct violence are rarely seen; this does occasionally occur in the knee and the acromio-clavicular joints. Sometimes dislocations are due to muscular action alone without the application of violence, as in the case of the patella, the jaw, and the shoulder, while in many cases the subsequent contraction of the muscles increases the displacement of the bones. The resulting deformity is often maintained by muscle spasm, and once this is overcome by anæsthesia spontaneous reduction may occur.

Dislocations are rare in children, as in their case it is easier for separation of epiphyses to occur; in the old fractures are more likely, so that dislocations are most commonly seen in adults. The mechanism producing a dislocation is leverage, as a rule applied by a long bone acting as a lever on a ligament as a fulcrum, as is seen in the case of the hip joint.

Varieties. These injuries may be either complete or partial, in which latter case they are known as subluxations, while they may be either purely traumatic and occur in a joint previously normal, or occur as the result of disease in a joint, in which case they are pathological.

Pathological dislocations occur in diseased joints; they are usually due to septic infection of joints, especially pyæmic infection, in which case they are painless and apt to be overlooked, to osteoarthritis, to tuberculosis, and to neuropathic joint disease; in some cases they are the result of gross deformities in the limb.

Occasionally, in accidents where there has been extreme violence, either from the destruction of tissue by the force of the injury or by perforation from within by one of the bone ends, the skin is torn and the condition then becomes a **compound dislocation.** This is a serious injury; in most cases a fracture will be present as well, and in this case we speak of the injury as a **fracture-dislocation.**

In addition dislocations are described as recent or old-standing, and as **complicated,** if injuries to vessels, nerves and other organs are also present.

The *signs* of a dislocation are :—

1. Deformity: palpable and obvious and usually of a standard type: it should be checked by measurements of the bony points. It is occasionally accompanied by mobility in a direction where there should be no movement, while the limb may be either lengthened or shortened and is usually increased in girth.

2. Loss of function: usually marked.

3. Swelling of the soft parts, followed later by discoloration.

4. Pain: local and referred, and usually severe from pressure on nerves and the stretching of surrounding structures. The limb below may be numb.

5. Unnatural rigidity, owing to the interlocking of bone ends and the stretching of muscles and tendons. A curious creaking sensation is sometimes felt on attempting to move the joint.

Results of Dislocations. These are such as are outlined under general effects of injuries to joints; considerable bruising and effusion of blood are nearly always present, the local damage being severe. Reduction is often difficult, partly owing to the anatomical disarrangement of the parts and partly to muscular spasm, but once reduction has been effected there is slight tendency to recurrence except in certain joints. Once a joint has been dislocated it probably will never be quite as strong as formerly, as adhesions and some degree of osteoarthritis are likely to follow and lead to a little pain and stiffness.

If allowed to remain unreduced, the true joint socket becomes shallow and indistinct, the articular cartilage undergoing conversion to fibrous tissue, which also fills up the joint socket. The rent in the capsule closes round the bone and firm fibrous adhesions form everywhere, while around the displaced head of the bone extensive fibrosis and atrophy of the muscles occur. The pressure of the head sometimes will form a new fibrous socket which may become lined with a secreting membrane, and in this way a **false joint** may be formed. If the displaced head of one bone presses on another bone, a bony socket for it may gradually be produced and the false joint come in time to resemble a ball and socket joint, especially if the patient is muscular and persists in using the limb. Some of these false joints are remarkably free and useful, but most of such unreduced dislocations give poor functional results, are painful from pressure upon nerves, and are followed by chronic *arthritic changes. In compound dislocations there are grave risks of septic* arthritis.

Treatment. It is always essential to have an X-ray photograph taken in case a fracture or crack in the bone is also present. As in the case of a fracture, reduction should be carried out as soon as possible, for the longer the delay the greater will be the difficulty in doing this. In carrying out reduction the anatomy of the part and the principles of leverage should be borne in mind. It is necessary, therefore, to relax the muscles and carry out suitable movements to cause the dislocated parts to retrace their course. For adequate relaxation of the muscles an anæsthetic is generally necessary, nitrous oxide being as a rule sufficient, but sometimes recourse must be taken to ether or chloroform, and in this case the patient should be carefully prepared beforehand. No amount of physical force will take the place of accurate knowledge of the anatomy of the dislocation, and all violent tugging movements must be avoided. After reduction suitable apparatus must be applied to prevent any risk of recurrence and physical treatment commenced. After two or three days active movements without weight bearing may be allowed, leading on to full active movements and later weight carrying and bearing, any special movement likely to lead to recurrence of the dislocation being carefully avoided. If reduction cannot be effected by manipulation and extension, it may rarely be necessary to proceed to open operation. A case in which this often has to be done is dislocation of the metacarpo-phalangeal joint of the thumb (see p. 481).

In **compound dislocations** treatment must be carried out on the same lines as in compound fractures. That is to say, if the case is seen early, the wounds should be excised and dead tissue removed, the joint reduced, and the capsule of the joint closed at all costs, but the superficial parts of the wound, if there be any doubt as to infection, be left freely open. If sewn up, all skin stitches should be removed on the first indication of infection. If not seen till after twelve hours, wound excision is useless and the joint cavity should then be closed, the superficial parts of the wound being left freely open and covered with an antiseptic dressing. The actual joint cavity always should be closed, even if pieces of fat or fascia have to be used for the purpose, as this is far more likely to ensure a mobile joint. The limb is immobilised on a suitable splint, and once sepsis is under control, physical treatment commences. In some cases of compound dislocation, where other severe injuries to the soft tissues are present, amputation is the only possible line of treatment.

Unreduced Dislocations. Here an attempt should be made to effect reduction. During the first six weeks there is a reasonable chance of effecting this by manipulation under an anæsthetic, though this will not be free from the risk of rupturing blood vessels or nerves and of fracturing the bone. After this time, if reduction is considered the best method, it must be carried out by open operation, and even then it may be a very difficult procedure. In some cases excision of the displaced head of the bone is the wisest course.

Recurrent Dislocations. These are seen in the shoulder, patella and jaw—that is to say, the joints that are easily dislocated by muscular action alone. They will be considered more fully under their respective headings.

(5) **Penetrating Wounds of Joints.** These may be brought about in a number of ways, most often by falls on spiked objects, rusty nails, knives, gunshot wounds, etc. They are very serious in that they provide an avenue whereby infection may reach the joint; it used to be thought that joints more easily than any other tissue in the body fell a prey to infection, but experience of gunshot wounds in the last war has modified this opinion. *Once infection is established septic synovitis or septic arthritis follows* (see p. 592), and the usual result—to take the most favourable view—is ankylosis, while amputation may prove necessary or the case progress even

to a fatal result. Thus it must be realised that such a perforating wound opens up these possibilities, and is therefore of the greatest seriousness.

Treatment. This resembles the treatment of compound fractures; in any recent injury penetrating the joint or in which it is considered possible that the joint may have been penetrated, the track of the wound should be cleanly excised and sutured, drainage of the soft tissues being employed for forty-eight hours down to but never into the joint cavity, the synovial lining of which should be closed by interrupted catgut sutures. After this the limb should be immobilised with an extension to secure separation of the joint surfaces, and antitetanic serum given. The probe should *never* be used in these cases as infection may be carried into the joint, but an indication of what has occurred will be given by the presence of a synovial effusion, which may consist of clear synovia or may be practically pure blood; the fluid (blood or synovia) often can be squeezed out of the wound if the joint cavity has been opened.

After an interval of more than twelve hours excision is valueless as a means of combating infection, and in this case any grossly destroyed tissue should be removed, the limb dressed and immobilised with an extension and reliance placed on the protective powers of the body. In all cases we have to keep a careful watch for the onset of infection, and if this occurs it varies considerably in intensity. Locally there will be pain, swelling, heat and considerable effusion into the joint, together with muscular wasting, spasm and rigidity. This spasm is protective in nature and prevents the inflamed articular cartilages rubbing together with consequent pain. The phenomenon known as "starting pain" may be present: as soon as the patient falls asleep the muscles relax, and the inflamed articular surfaces rub together, producing pain and sudden spasm of muscles, this causing the patient to wake with a start.

There are associated toxic effects of varying severity and chemiotherapy should be tried in all such cases. The pulse is rapid, the temperature high and of remittent type, and rigors are frequent. Unless the joint condition is treated energetically, the general condition of the patient deteriorates rapidly and septicæmia or pyæmia ensues, while the infection often spreads outside the joint cavity and runs up and down the muscles of the limb.

When infection is suspected the wound, if tightly sutured, must be opened up freely and irrigated with an antiseptic. The joint cavity should be aspirated and the nature of the fluid examined macroscopically and microscopically. If frank pus is present the joint should be opened up and drained at once from its most dependent point as the patient lies flat. Drainage tubes should be passed down to the incision in the joint, but not across the articular cavity, otherwise destruction of cartilage and resulting ankylosis are inevitable.

If the fluid is turbid its bacteriology should be determined, suitable antisera given and the case watched for a further twenty-four hours. On no account must the joint be washed out, even with saline, but aspiration may be repeated to allow ingress of fresh synovial fluid.

If, as a result of aspiration, there is obvious improvement, the joint may be treated expectantly, aspiration being repeated as necessary, but even after several weeks of this it may be necessary to open and drain the joint.

Often aspiration fails to relieve in the first place, and then the joint should be opened at its most dependent point, pus allowed to escape, the synovial membrane closed by suture, and the superficial parts drained. The anatomical peculiarities of the particular joint must be borne in mind when providing drainage.

This hesitation to drain a joint immediately is due to the fact that once a joint is opened and drained, ankylosis is the rule.

It must be stressed that there is considerable risk that a patient will die of general infection from a septic joint, and if the course of the case indicates it, amputation must be resorted to and not postponed until even life itself cannot be saved. Careful splintage with extension to support and rest the joint must be applied from the first, as it is by this means alone that the infection and necrosis of the cartilages, which follow inevitably unless these are kept apart, can be prevented, and subsequent deformity avoided. (*See* Special Joints, Chapter XX.)

Once infection is controlled physical treatment may be commenced, but special caution must be exercised, as in this type of case particularly latent infection is prone to light up.

In a neglected case pathological dislocation and complete disorganisation of the joint may occur, and care should be taken that when ankylosis is likely to occur, it should do so in suitable position. Bony ankylosis is the rule but rarely fibrous ankylosis results, and with caution the adhesions may be broken down under anæsthesia or be corrected by gradual extension. If ankylosis has occurred in bad position, fresh ankylosis by excision or arthroplasty may be resorted to, or if considered better, osteotomy of the neighbouring bones undertaken.

Gunshot Wounds of Joints. These vary greatly in extent : there may be a perforation of the capsule and synovial membrane only by a bullet or small shell fragment, a hole cleanly drilled through the bones, or a complete shattering of the bony surfaces and disorganisation of the joint. The latter cases will require amputation, but if the other slight cases are treated on the above lines by excision and suture of the capsule, followed by proper splintage, it is quite likely that no intra-articular infection will occur (*see also* Appendix).

Manipulation of Joints. Not uncommonly adhesions form in and around a joint following injury. The commonest case is probably that of the shoulder joint, where peri-articular adhesions from tearing of the capsular structures are found, while intra-articular adhesions also occur as a result of previous bruising and hæmorrhages. As a result limitation of movement, notably adduction, persists and is not benefited by treatment aimed at restoring muscular power, that is to say electrical treatment, or at reducing stasis, that is to say massage.

In these cases manipulation under nitrous oxide anæsthesia is particularly useful in breaking down the adhesions and restoring a full range of movement.

After some manipulations it is common to find a considerable degree of effusion into the joint and increase of pain, which are, however, transitory.

In cases where manipulation is likely to be prolonged full general anæsthesia will be required.

A golden rule in breaking down adhesions in joints is to be content with doing a little at a time. Only two, or at most three, adhesions should be felt to break each time, and the process may be repeated after a few days' interval. This is the only way of avoiding severe reactions.

CHAPTER XVI

INJURIES OF THE UPPER LIMB

Surgical Anatomy and Methods of Examination. In the neighbourhood of the shoulder and upper arm the injuries that may be met with consist of fractures of the clavicle, dislocations of the joints at either end of it, fractures of the scapula, dislocations, sprains and contusions of the shoulder joint and fractures of the upper end of the humerus. Rupture of the muscles, such as the biceps and its tendons, are also seen here, but they are described on pp. 381—384.

In *the examination of an injury* in this situation it is of great importance that the surgeon should make a careful inspection of the patient, who should be placed standing in front of him, in a good light, and stripped to the waist. The two shoulders are then compared visually before any palpation is undertaken, special regard being paid to any obvious asymmetry, the presence of abnormal swellings or hollows or to an unusual position of the limbs. Palpation is then performed, carefully contrasting the two sides. The normal bony points which can be felt subcutaneously and which should be compared on the two sides of the body are the sternum, suprasternal notch, the inner end of the clavicle, the sternoclavicular joint and the head and whole length of the clavicle, including the deltoid tubercle and its acromial end. The whole acromion can be felt, which is sometimes rough and ridged, while the fingers can be passed down along the length of the spine of the scapula, which may be palpated as far as the vertebral border of the bone, and the movements of the body of the bone may be examined. In front the coracoid process can be felt immediately below the outer part of the clavicle in the upper and outer part of the triangular depression which will be found there.

The greater part of the head of the humerus is buried under the deltoid, but the head and upper part of the neck may be felt from the axilla if the arm is close to the side. It must be remembered that the great tuberosity lies vertically above the external condyle of the humerus and may sometimes be felt rotating under the deltoid; while in those instances where there is an injury in the neighbourhood of the shoulder, the direction the internal condyle of the bone is pointing in shows the direction in which the glenoid surface of the humerus is pointing, provided there is no fracture. The epiphysis of the inner end of the clavicle lies entirely within the capsule of the sternoclavicular joint, and unites with the shaft of the bone about the twenty-fifth year. The epiphysis of the upper end of the humerus is a compound one, consisting of three separate portions which fuse together; it is partly intra-articular and partly extra-articular. The main epiphysis unites with the shaft of the bone about the twenty-fifth year, and it is at this epiphysial junction that the growth in length of the humerus chiefly occurs. Damage to or disease in the epiphysial line here, therefore, may lead to great shortening of the bone.

In measuring the length of the arm to compare it with the other side, it is usual to take the angle where the acromion meets the spine of the scapula as the upper fixed point, and to measure from here to the external epicondyle.

Effusions into the shoulder joint are not uncommon, and they give rise to prominence and swelling of the deltoid; fluctuation is difficult to obtain in this situation, but a fluctuating swelling will usually be felt bulging into the axilla.

In the neighbourhood of the elbow there are several subcutaneous bony points of great importance. Both the condyles and epicondyles of the humerus can be felt, the internal one being much the more prominent. They are both on the same level, and the line joining them just crosses the tip of the olecranon process when the elbow is fully extended. When the elbow is fully flexed the tip of the olecranon passes down from this line and the above three bony points then come to form roughly an equilateral triangle. The whole of the olecranon process with its tip is subcutaneous and can be felt to be continuous with the posterior border of the ulna (also subcutaneous), by running the finger down the back of the forearm. The head of the radius is also subcutaneous and can be felt in the dimple on the back of the forearm about ¾ inch below and inside the external condyle of the humerus. The head of the bone can be felt rotating here. It is usually also possible to feel the coronoid process of the ulna by pressing deeply in the antecubital fossa. When fully extended and supinated the arm and forearm are not straight, but form an obtuse angle open on the outer side and known as the "carrying angle." This angulation is rather more marked in women than in men.

When an effusion occurs into the elbow joint the whole region will be swollen, but the effusion will be palpated most easily and probably fluctuation obtained at the back of the joint on either side of the olecranon process. On the front of the joint the biceps tendon will be seen and felt, while immediately under this tendon lies the termination of the brachial artery, and behind and just to the inner side of it the median nerve. The ulnar nerve is found lying in the groove behind the internal condyle and between it and the olecranon process. It is very liable to injury at this point.

On examining a patient who is suspected of an injury in this neighbourhood it is absolutely essential to compare the two arms by placing them in exactly corresponding positions. The fingers are then placed upon the two condyles and the olecranon process and the position of these three bony points compared on the two sides both at rest and in motion, while the rotation and position of the head of the radius should be tested carefully.

The presence of the epiphyses in connection with the bones entering into this joint must be carefully remembered, as otherwise in an X-ray photograph in young patients difficulties in interpretation may occur.

In the forearm the whole of the posterior border of the ulna can be felt to be subcutaneous, while the greater part of the lower half of the radius, especially on its outer surface, can also easily be palpated.

In the neighbourhood of the wrist the lower ends of both ulna and radius can be felt easily and examined, while the various tendons running across these bones can be identified in their individual grooves. The styloid processes of the ulna and radius must be carefully distinguished; that of the ulna lies at the back of the wrist, where it can be felt distinctly projecting beyond the head of the bone; the radial styloid process is best felt in the anatomical snuff box. It lies about ⅓ or ½ inch lower than the ulnar styloid and considerably more anteriorly. About the centre of the back surface of the lower end of the radius the radial tubercle can be felt.

With the hand in the fully supine position the tubercle of the scaphoid and the rough surface on the trapezium can be felt below and rather inside the styloid process of the radius, while with the arm in the same position the pisiform and the hook of the unciform can be felt slightly below and outside the head of the ulna.

The backs and the sides of the metacarpal bones and the greater part of the phalanges are all easily palpable, while on acutely flexing the wrist a rounded prominence will be noticed just below the wrist joint on the back of the hand; this is formed by the bases of the second and third metacarpal bones. It must not be forgotten that the prominences of the knuckle are in every case formed by the head of the proximal one of the two bones entering into the knuckle joint; the actual joint line, therefore, is in every case some little distance distal to the prominence of the knuckle.

In examining a case of suspected injury in this neighbourhood it is again of the greatest importance to compare the two sides and to contrast the relative positions of the different bony points and the power and range of movements of the various joints.

In the treatment and diagnosis of all injuries, it cannot be too strongly insisted upon—

(1) that an X-ray photograph must be taken.

(2) That if a fracture is present, a general or local anæsthetic should be given for its reduction.

(3) That another X-ray picture must be taken afterwards to ensure that reduction has been accomplished properly.

FRACTURES OF THE CLAVICLE

This is one of the commonest fractures met with in the body; it is often a greenstick fracture, and frequently occurs in early life. It is very seldom compound, unless due to gunshot wounds, and usually unites well, giving very good functional results even with an indifferent anatomical result.

The *cause* is indirect violence due to a fall on the arm or point of the shoulder, and hence, if the fracture is in the shaft, the common site, it is spiral. This injury is most commonly met with on the hunting field, racecourse or football ground. Occasionally fractures of the middle portion of the bone are due to direct violence, such as blows on the bone. It may break (1) in the shaft, (2) at the outer end, (3) at the inner end.

(1) **In the Shaft.** This is the common site. The direction of the fracture is usually downwards and inwards and, as a result, the outer fragment is dragged down, inwards and forwards by the weight of the arm and the pull of the pectorals, while it is also slightly rotated. Occasionally pressure upon or injury to the axillary vessels and nerves results. The inner fragment remains fixed to the underlying first rib by the rhomboid ligament, and usually overrides the outer fragment (see Plate II.).

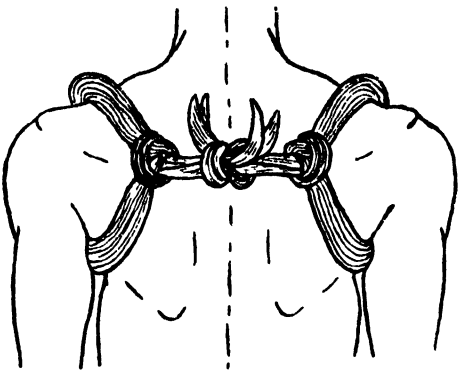


FIG. 225. The three-handkerchief method.

Power is lost in the arm, the patient supporting it with the opposite hand and holding his head inclined towards the injured shoulder to relax the sterno-mastoid. The fracture is usually palpable and crepitus is elicited easily.

Occasionally, particularly in crushing accidents, the lesion is bilateral, in which case, owing to the weight of the helpless arms and the uselessness of the accessory muscles of respiration, breathing may be embarrassed to a considerable degree, and the patient will be particularly helpless, as he cannot use either arm. This must be regarded as a serious injury.

Reduction is effected by pulling back and levering out the shoulder with a fist in the axilla and supporting the weight of the forearm while leaving the elbow hanging free, for as Böhler points out the thorax is like a barrel and the lower the shoulder hangs the less the overlap at the site of fracture. This is most conveniently done with the patient lying on a couch, while an anæsthetic, if necessary, may best be given in the form of local injection of 2 per cent. novocain between the fragments.

Treatment. The fragments may be fixed in several ways, those in common use being (1) the three-handkerchief method, (2) Sayre's method, (3) Wharton Hood's method, (4) the adoption of the recumbent position.

(1) *The three-handkerchief method.* Two handkerchiefs or slings are rolled lengthwise round a thick strand of wool, then passed over the point of each shoulder through each axilla and loosely knotted behind the back of the shoulders. By knotting the ends together in the middle line the shoulders are braced back (Fig. 225). The third handkerchief is used as a sling to

support the forearm of the injured side. We regard this as the best routine method.

(2) *Sayre's method.* A pad of wool is placed in the axilla and a loop of broad three-inch adhesive strapping is passed round the upper arm, sticky side outwards, the loose end being secured with a pin, and the long end carried round the back across the front of the thorax to the back of the arm, being fixed to itself just beyond the loop; this pulls back the arm. A second strip is now applied from the top of the sound shoulder across the back to the point of the elbow on the injured side, with a notch cut in the plaster fitting over the olecranon. This pulls the elbow well forward. It is then carried on across the front of the dorsal aspect of the forearm, which is flexed with the fingers touching the sound shoulder, back to the starting point. The whole is secured with a flannel bandage. This method produces unnecessary fixation of the elbow and hand, limiting remedial massage and mobilisation, while it may produce venous congestion from excessive pressure. *Chiene's* modification, using flannel bandages in lieu of strapping, is preferable.

Both these methods are unsatisfactory in that the arm on the injured side cannot be used; this can be avoided and the arm left free by the use of the somewhat complicated apparatus advocated by Böhler.

(3) *Wharton Hood's method.* Two-inch adhesive plaster is used and three long strips are taken, passing from the inferior angle of the scapula on the sound side, up the back diagonally, over the site of the fracture with a pad intervening, and diagonally downwards in front to the opposite side of the chest. The other two strips are slightly divergent, but cross over the site of fracture. The forearm is supported in a sling.

This method is applicable where early use of the arm to some extent is imperative, *e.g.*, in jockeys. The sling may be discarded in ten days and undershoulder movements of the arm permitted.

(4) *The recumbent position.* Where the fracture is bilateral or in young or attractive ladies, in whom a perfect cosmetic result is essential, this is the method of choice. The patient is nursed absolutely flat on a firm mattress, with a small sand pillow between the scapulæ. The arm is slightly abducted. This position is retained for three weeks, and proves too irksome for most patients.

After-treatment. Finger movements and elbow movements should be commenced from the start under the guidance of a trained masseur, while the three handkerchiefs or other fixation may be discarded in three weeks and the sling before. After the second week passive movements of the shoulder joint may be started leading on to full active movements in the third. No heavy use of the arm should be permitted under two months, but light work may be commenced about the fourth or fifth week.

Complications. As mentioned above, these are rare. Injury of vessels or nerves will require appropriate treatment (see p. 327). Non-union is very rare, and even with fibrous union a useful functional result is obtained, so that operative treatment is seldom, if ever, necessary, save that occasionally in bilateral or compound cases it may be required; at times excessive masses of callus form in badly treated cases, and they may need removal.

Results. Firm, bony union generally occurs within twenty-eight days. From the functional point of view the results are excellent, but bony deformity usually will be noticed and the bone may be shortened slightly.

(2) **At the Outer End.** Fracture of the outer end is of the interligamentous type, the clavicle being broken across the coracoid process like a stick across

one's knee, so that in this case there is no displacement and the only symptoms are pain, tenderness and swelling at the site of the fracture. The fragments are splinted by the conoid and trapezoid ligaments. If the fracture is external to these, the outer fragment is displaced downwards and forwards, being rotated so as to bring the tip of the shoulder nearer the midline. There is no dropping of the shoulder and arm as a whole, as the conoid and trapezoid ligaments are intact.

Treatment. If no displacement is present a sling is all that is necessary, while if the shoulder is dropped the device shown in Fig. 226 should be used. This is a bandage passed over a felt or sticking plaster pad on the olecranon up over another pad on the top of the shoulder and knotted on this, pulling up the elbow. The two ends are then passed under the axilla of the opposite side over a third pad and tied there. The arm is supported in a sling.

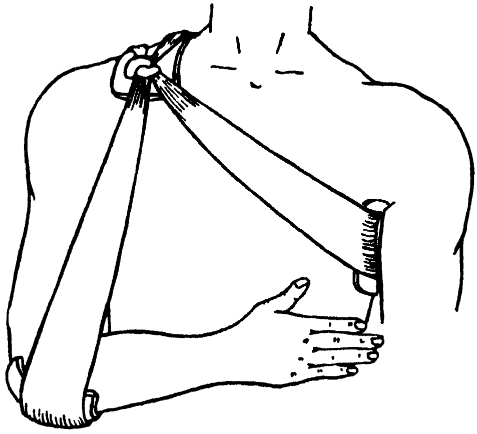


FIG. 226. Treatment of a fracture of the outer end of the clavicle.

The after-treatment and results are similar to those given above, save that in a fracture without displacement the sling may be discarded in fourteen days and movements permitted earlier.

(3) **At the Inner End.** Fracture of the inner end is rare, and most often in the nature of a separation of the epiphysis. Displacement is as a rule slight, unless the rhomboid ligament is torn, in which case the inner fragment tilts up; a sling for three weeks is the only fixation necessary.

Separation of the Clavicular Epiphysis. This is a rare accident, which may occur between the ages of sixteen and twenty-five. The signs and symptoms are the same as those of a fracture of the inner end of the clavicle (see above). The treatment is also the same.

DISLOCATIONS OF THE CLAVICLE

These may occur at either end.

(1) **The Sternal End.** Dislocation here is usually only partial and the bone may pass forwards, backwards or upwards; usually the first variety occurs.

(*a*) *Forward variety.* Here the end of the clavicle can be seen and felt lying on the sternum just below its proper socket; the rhomboid ligament remains intact.

(*b*) *Backward variety.* This is rare, the head of the bone in this variety lying behind the sternum and the sternohyoid, sternomastoid and sternothyroid muscles, while there is a hollow where the inner end of the bone should be. It has sometimes happened in this injury that the end of the clavicle has produced pressure upon the trachea, œsophagus or subclavian vessels. The rhomboid ligament is usually intact also.

(*c*) *Upward variety.* Rarely the rhomboid ligament gives way, and then the head of the bone passes up to lie in the episternal notch behind the sternomastoid.

The dislocations are easy to reduce, but difficult to keep in place, and they tend to recur. Imperfect reduction, however, interferes very little with the function of the limb. The treatment is similar to that of a fracture of the inner third of the clavicle; the condition is liable to be followed by osteoarthritis of the joint.

(2) **The Acromial End.** This is the commoner injury by far, and is produced by falls on the point of the shoulder, in which case the clavicle rides up over the acromion; rarely the injury is caused by a blow on the clavicle, and then this bone may be pushed down below the scapula and press upon the capsule of the shoulder joint. (Plate II.)

Rarely dislocations of both ends of the clavicle have occurred as the result of severe crushes.

The condition is easy to recognise, as the displaced end of the bone can be seen and felt and there is acute tenderness over the joint; the tip of the shoulder is slightly displaced downwards and forwards and the head inclines to the injured side; the muscles attached to the displaced clavicle may be taut, while the patient has difficulty in abducting his arm above the shoulder.

Reduction is easy, but the displacement tends to recur, and it is doubtful if permanent or complete reduction ever occurs. Even if the displacement persists the efficiency of the arm may be unaffected.

Treatment is similar to that given for a fracture of the outer end of the clavicle with displacement. Cases have been treated by wiring or arthrodesis, but the results are disappointing. The functional result, with ordinary conservative treatment, is usually good, though the injury is often followed by osteoarthritis of the joint (see p. 656).

FRACTURES OF THE SCAPULA

These are of several distinct types: (1) Fracture of the body. (2) Fracture of the acromion. (3) Fracture of the neck. (4) Fracture of the coracoid process. (5) Fracture of the glenoid. They are very rarely compound.

(1) **Fracture of the Body.** This is a rare injury on account of the mobility and muscular support of the bone; it is caused by direct violence, usually the result of crushes which produce cracks and fissures running across the curves of the bone, often in the infraspinous fossa. The fracture is associated with much local bruising and extravasation, which may mask its features. Severe pain on movement is always present, but crepitus is not likely to be elicited unless the spine is broken off and can be moved about upon the rest of the bone. Insomuch as it is splinted by the surrounding muscles, displacement is slight or absent, and an X-ray photograph will be necessary; union usually occurs rapidly and leaves no permanent incapacity. The shoulder, however, may remain painful for many months.

Treatment consists in strapping that side of the chest as for a fracture of the ribs and supporting the arm in a sling, which should be retained for three weeks, giving daily massage and movement of the joints. Full work may be commenced in six weeks. These injuries are frequently accompanied by other injuries to the trunk and thorax, which may cause much shock and necessitate rest in bed.

(2) **Fracture of the Acromion Process.** This is rare and due to direct violence, such as falls on the shoulder. Clinically it may resemble a fracture

of the outer end of the clavicle with displacement (see p. 449), and it gives rise to bruising, irregularity and possibly crepitus at the site of the fracture, while the shoulder may appear slightly flattened and abduction of the arm be difficult and painful. This fracture is sometimes overlooked. Its treatment is the same as that of a fracture of the outer end of the clavicle (see p 450).

Non-union or fibrous union of this fracture is not uncommon, and when this has occurred the condition has been described many years after the injury as a "separate acromion." This condition is also seen as a result of non-union of the epiphysis.

Separation of the acromial epiphysis may occur before the twentieth year; the features and treatment are the same as in the above injury.

(3) **Fracture of the Neck.** This is rare. The line of the fracture usually runs from the scapular notch to the lower border of the glenoid, so that the coracoid process is usually separated with the glenoid; consequently the conoid and trapezoid ligaments are torn, with the result that the whole arm sinks, and there is real lengthening on measuring from the acromion to the external epicondyle of the humerus, with flattening of the shoulder and a hollow below the acromion. At first sight it may be confused with a dislocation of the shoulder, but it will be found that the coracoid process moves with the arm. Reduction with anæsthesia is easy, but the deformity tends to recur immediately.

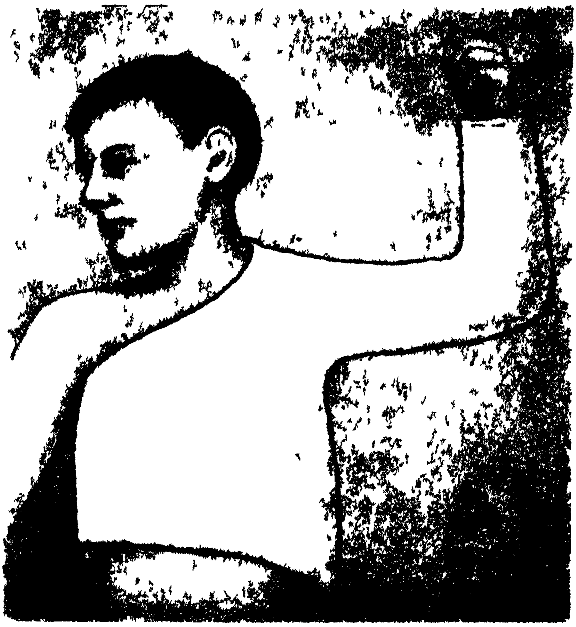


FIG. 227. Shoulder spica.

Treatment is as outlined for a fracture of the outer end of the clavicle with displacement, but should occupy rather longer than in that injury.

No heavy work should be undertaken for three months.

(4) **Fracture of the Coracoid.** This is rare. It may result from direct

violence from a blow or be associated with dislocation of the clavicle or of the shoulder, or be a traction-fracture due to the pull of the muscles attached to it. If the conoid ligament remains intact there is no displacement, but otherwise the process is pulled down and out. Occasionally the epiphysis is separated before the eighteenth year.

Treatment consists in applying a sling for three weeks.

(5) **Fracture of the Glenoid.** This sometimes complicates a dislocation of the shoulder, and should be suspected if the dislocation recurs easily after reduction. Being a fissured fracture into a joint, it is liable to produce troublesome arthritic changes.

Treatment consists in fixing the shoulder in abduction to 90 degrees in a well-fitting plaster of Paris spica (Fig. 227). A metal abduction splint may be used, but it is not so satisfactory. The splint is retained for three weeks, and after this it is retained as a gutter during the day and massage and movement commenced. After four weeks a sling is used for a further two weeks and movements increased. No heavy work should be allowed for ten weeks.

The results in those of middle age and over are disappointing, stiffness and limitation of full abduction being the rule.

FRACTURES OF THE UPPER END OF THE HUMERUS

(1) **The Anatomical Neck.** This is commonest in elderly people and is due to direct violence. It is usually impacted, and often comminuted, several fragments being present, while in a few instances the line of fracture is entirely intracapsular and the head of the humerus may lie completely loose in the joint. In severe cases the head may be dislocated. Slight flattening of the shoulder and shortening of the arm will be present, while local extravasation and bruising are usually extreme, and care must be taken in handling the case not to produce disimpaction. An X-ray photograph should always be taken, and sometimes this will show the fracture to be present in cases where it was not suspected.

Treatment consists in applying a sling and commencing massage at once. After a week passive movements of the shoulder may be commenced, but special caution must be taken in allowing rotation, as refracture and disimpaction are produced easily. The sling should be retained for three weeks and no heavy work be allowed for two months. If portions of the head are grossly displaced they should be excised. Some surgeons prefer to treat this fracture with the limb abducted in an extension splint, but in our experience no better results are obtained and the method is tedious to the patient, who must be confined to bed.

The results are often disappointing from osteoarthritic changes developing, with marked limitation of movement.

(2) **The Surgical Neck.** The surgical neck of the bone is that part of it between the epiphysis and the insertion of pectoralis major ; fractures here are fairly common, may be caused by either direct or indirect violence, and are often impacted. There is usually a transverse fracture, with much swelling and bruising ; there may be little displacement, but it is usually found that the lower fragment is drawn upwards and inwards by the muscles inserted into it, so that its upper end can be felt in the axilla. The upper fragment may be rotated outwards and abducted so that angulation will occur, but this is not constant. The shoulder remains round and is not flattened, the arm on measurement is usually slightly shortened, while the head and

tuberosities can be felt not to rotate with the shaft of the bone. Crepitus and unnatural mobility may be detected, while there is great pain and swelling from pressure upon vessels and nerves. In most cases the fracture can be distinguished easily from a dislocated shoulder, but this latter injury may also be present.

Treatment. If deformity is gross, it should be corrected under anæsthesia by long axis traction applied with the arm *adducted* across the body. The fracture being transverse, locking with little tendency to redisplacement will occur. If reduction cannot be carried out by manipulation, the question of effecting it by open operation should be considered, in which case the fracture should be exposed by an incision along the anterior border of the deltoid. After reduction a collar and cuff sling (Fig. 231) is applied and the arm bandaged to the side. The after-treatment consists in early use of the joints of the limb with movement of the shoulder at the end of ten days, and active movements in three weeks, while the sling should be retained for a month, as there is a risk of refracture. If after reduction redisplacement occurs on adducting the arm, the fracture must be treated in abduction in a plaster spica or on an abduction splint, this should be retained for three weeks.

The results are usually good as regards function, even with a poor anatomical result, with the exception of the case of the elderly, in whom stiffness of the shoulder is often a persistent complication.

The circumflex nerve is occasionally involved in this injury (see p. 359).

(3) **Fracture of the Morphological Neck (Separation of the Epiphysis).** This is a separation of the upper epiphysis, which includes the head and both tuberosities and unites about the twenty-fifth year. The injury is seen most commonly in males from eight to fifteen years of age. It is produced by the same violence that would produce dislocation of the shoulder or fracture of the surgical neck in an older subject. If displacement occurs the head commonly passes inwards and backwards, while clinically the condition will resemble a fracture of the surgical neck, the age of the patient, the X-ray appearances and the muffled crepitus distinguishing it.

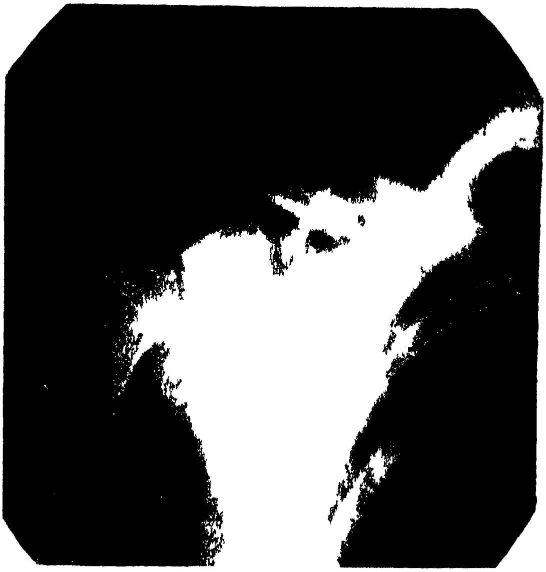
Treatment. If it is impacted in good position the treatment is similar to that for a fracture of the anatomical neck, and in this case a sling, with the arm bandaged to the side for ten days, is sufficient. Finger and elbow movements are permitted from the start. After ten days movements of the shoulder may be commenced, with special care in abduction, and after three weeks active movements may be started. The sling is discarded in four weeks.

If deformity is present, reduction under anæsthesia should be attempted and the arm fixed in abduction and external rotation in a plaster for three weeks. Reduction may be difficult on account of the small size of the upper fragment and the interposition of soft tissues, and if it cannot be effected by manipulation, open reduction should be carried out.

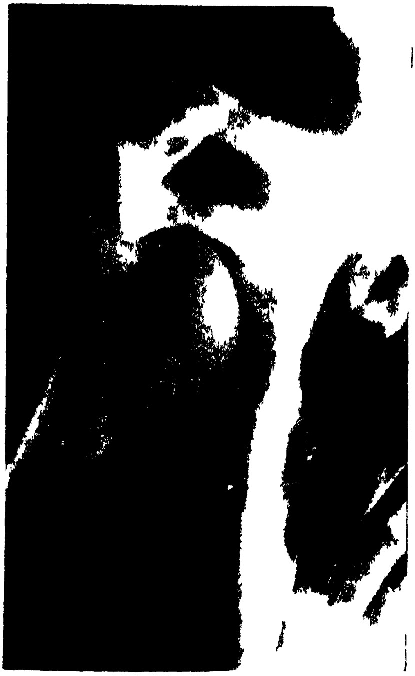
The results are usually satisfactory, but occasionally some interference with growth occurs, as it is at this end that growth of the bone chiefly takes place.

(4) **Fracture of the Greater Tuberosity.** This occurs more commonly than is realised, and consists in a tearing off of the tuberosity ; unless routine X-ray photographs of shoulder injuries are taken, it often may be missed. It is caused as a rule either by muscular action, often with dislocation of the shoulder, or by direct violence, and once detached the loose fragment is pulled upwards and backwards under cover of the acromion by the muscles inserted into it. This produces gross limitation of abduction. Extravasation over the shoulder joint is often present, while great broadening of the bone

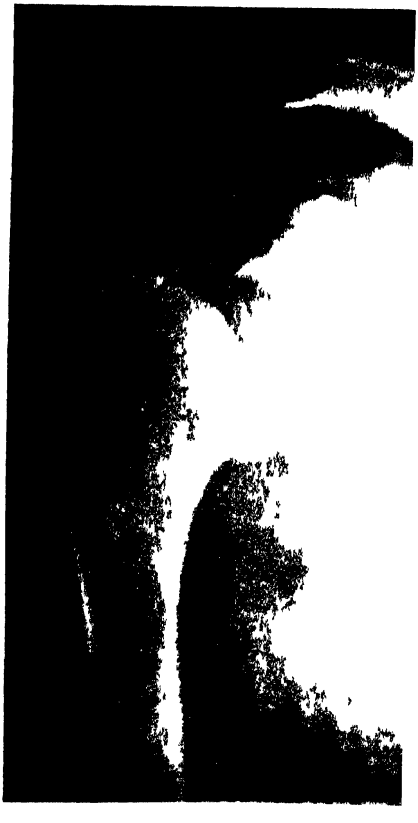
PLATE II



Fracture of the middle third of the clavicle



Subglenoid dislocation of the shoulder with fracture of the great tuberosity



Dislocation of the acromico-clavicular joint.

To face

may be detected and crepitus is usually felt on rotating the humerus. Adduction of the arm will cause severe pain by separating the fragments, and this is the only injury in which this occurs.

Treatment. Reduction may be effected by bringing up the humerus to meet the loose fragment, *i.e.*, by abduction, but occasionally open operation with pegging on or, if impracticable, excision of the loose fragment may have to be resorted to.

After reduction, the treatment consists in applying a shoulder plaster spica with the hand at the back of the neck or an abduction splint with the arm abducted to 70 degrees for three weeks, commencing massage as soon as possible. Active movements of the shoulder may be allowed in three weeks and adduction to the side in four weeks. Consequently the splint may be discarded in four weeks, but a sling should be worn for a further four weeks.

Subsequent limitation of movement in the shoulder joint is a very common sequel from adhesions or arthritis, even when this treatment is carried out.

DISLOCATIONS OF THE SHOULDER

This is by far the commonest dislocation occurring in the body as a result of the exposed position, the free movements, the shape of the joint surfaces, and the weak ligaments. If it can be said to occur in any particular type of patient, it is most often seen in muscular adult males or obese middle-aged women. It is usually produced by a fall on the hand or arm with the arm abducted, and may be produced easily in an unconscious patient. The head of the humerus is pushed out through the weak lower part of the capsule between the subscapularis and teres major tendons, the muscles, which are the main source of stability in the joint, being taken unawares; when the arm is severely abducted it is probable that the humerus hitches against the acromion as a fulcrum and the head is forced out this way.

This dislocation is divided into four types from a consideration of the situation of the dislocated head: (1) Subcoracoid, a common type, (2) Subclavicular, (3) Subglenoid, (4) Subspinous.

(1) In this case, which is by far the commonest variety, the head leaves the weak antero-inferior part of the capsule, occupying for a short space the subglenoid position (see below); it then passes forwards and inwards under cover of the tendons of the biceps and coracobrachialis and is pulled up under the coracoid process by spasm of the subscapularis muscle. It is this muscle that forms the principal bar to reduction.

(2) This is merely a more extreme degree of (1), where the head of the bone passes under the pectoralis minor and presses up against the clavicle, and is a rarer occurrence.

(3) This is the initial stage of any of the other varieties, in which the head stays below the glenoid and lies on the long tendon of the triceps without passing forwards or backwards; in this position the head of the bone is in unstable equilibrium, so that it is not likely to remain here long, but passes on to one of the other forms, depending upon the direction of the force and the position of the limb. A variety of this dislocation is the *Luxatio Erecta*, a subglenoid dislocation with hyper-abduction of the arm, which points above the patient's head.

(4) Occasionally, instead of passing forwards, the head passes back on to the infra-spinous fossa of the scapula.

Shoulder Dislocations in General.

The signs of dislocation of the shoulder which are common to all the above varieties are :—

(1) Great pain, often with numbness of the limb.

(2) Flattening of the normal contour of the shoulder, the acromion being unduly prominent and the rounded curve of the deltoid being absent (Fig. 228). The patient stands with his head bent towards the injured shoulder and supports the forearm with the other hand.

(3) Hamilton's Ruler Test, in which a straight line can be dropped from the acromion to the external epicondyle of the humerus with the arm adducted to the side, an impossibility in the normal subject. This is rendered possible by the flattening of the deltoid owing to the absence of the humeral head.

(4) Emptiness of the glenoid, the displaced head being palpable elsewhere, while the arm is usually held fixed with the axis of the humerus away from the side. The position where the head can be felt will settle which type of dislocation has occurred.

(5) Dugas' sign, *i e.*, inability to touch the point of the shoulder on the opposite side with the fingers while the arm is adducted to the side.

(6) Marked fixity and rigidity of the arm.

(7) Lowering of the anterior or posterior axillary fold (Bryant's test).

(8) Alteration in the length of the limb.

(9) Increase in the vertical measurement of the axilla (Callaway's test) ; this measurement is made by passing a tape vertically round the axilla and comparing the two sides ; it is a most important aid to diagnosis.

Local bruising and extravasation are usually well marked.

Complications. (1) Fracture of the upper end of the humerus often comminuted.

(2) Fracture of the glenoid, which is indicated by easy recurrence of the dislocation.

(3) Fracture of the coracoid process or acromion resulting in what is sometimes known as a *supracoracoid dislocation.*

(4) Damage to the brachial plexus or circumflex nerve.

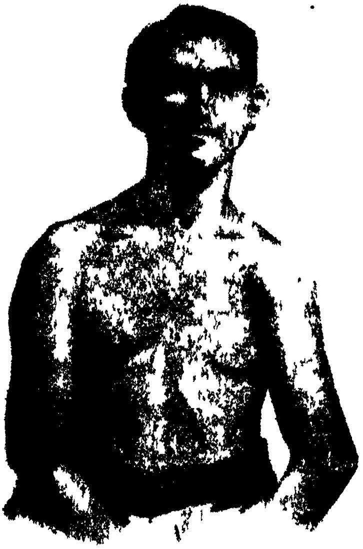


FIG. 228. Subcoracoid dislocation, showing flattening.

Reduction. Occasionally this occurs spontaneously on the patient attempting some effort such as removing the jacket, but usually manipulation is necessary, and for this an anæsthetic should be given with the usual precautions. The patient should be recumbent upon a firm couch, and nitrous oxide will usually prove sufficient, though ether is sometimes necessary. The guiding principle in reducing all dislocations is to endeavour to make the head of the bone return and enter the joint by the path by which it left it, and the main obstacles to reduction are muscular spasm and entanglement of the head of the bone in ligaments and tendons.

Kocher's Method (for a Subcoracoid Dislocation). This aims at overcoming spasm of the subscapularis muscle. The arm is kept to the side, and the elbow, having been flexed to a right angle and the forearm being utilised as a lever, is rotated slowly and steadily outwards until the position of extreme eversion is attained. Time must be taken over this, and it must be done evenly. Eventually the subscapularis muscle will be felt to relax, while this movement causes the rent in the capsule to gape open. The next two movements aim at making the head retrace its course. Keeping the arm externally rotated, the point of the elbow is carried forward and upward towards the opposite shoulder, the extension being maintained throughout, so that the upper arm is brought across the chest and the arm finally strongly internally rotated so that the hand passes over the opposite clavicle, when reduction should take place.

Reduction by Extension. (*Miller's Method.*) In this method the arm is abducted and pulled upon until the muscles are felt to relax, the forearm being held horizontally forward. During this time the head of the bone has been steadied with the hand, and on relaxation of the muscles it can be guided into position, being aided by a few rotatory movements and dropping the hand and forearm into the vertical position.

To apply this method efficiently counter-extension is necessary, and this is best supplied by a roller towel passed round the chest and pulled upon by an assistant on the opposite side of the couch. The practice of placing the unbooted heel in the axilla (which was that recommended by Hippocrates) is to be strongly condemned, as it may produce serious injury of the great vessels and nerves. If the unbooted heel is to be placed anywhere it should be placed against the side of the chest wall. The method of hyperabduction of the arm above the shoulder while traction is being made will sometimes succeed.

Smith's Method. For anterior dislocations, the surgeon stands in front of the patient and steadies the head of the bone with the thumb and the scapula with the fingers of one hand, right hand for right shoulder, left hand for left. With his other hand he abducts and everts the arm to a right angle and then circumducts inwards, guiding the head of the bone with the thumb.

For posterior dislocations the surgeon stands behind and, grasping the shoulder with one hand, extends and circumducts the arm with the other.

After-treatment. There is little tendency to re-displacement unless a fracture is present as well (*vide* Fracture of the Glenoid, p. 453, and Fracture of the Great Tuberosity, p. 454). The arm is placed in a sling and full massage commenced at once, with active movements of the fingers, wrist and elbow. Active movements of the shoulder in every direction except abduction, with the patient recumbent on a couch, may be commenced after three days; abduction should not be permitted for ten days. Active movements in the erect attitude may be commenced in seven days, and the sling discarded in ten days, when gymnastic exercises may be commenced. No heavy work should be undertaken for four weeks.

Subcoracoid Dislocation. This is by far the commonest form, and may be regarded as the typical shoulder dislocation, it being the result of forced abduction. The anatomical neck of the humerus hitches up against the edge of the glenoid cavity of the scapula and actually may be indented by it, while the subscapularis and the muscles inserted into the great tuberosity are stretched and taut. Injury to the brachial plexus or the circumflex nerve is especially common in this dislocation. All the clinical features described on p. 456 will be present in this dislocation, while the flattening is very marked and the head can be palpated in its abnormal situation; in addition the upper arm will be shortened. The arm is held fixed in considerable abduction. (See Plate II.)

The dislocation may be reduced by any of the methods described, Kocher's method being especially suitable.

Subclavicular Dislocation. This is an exaggerated degree of the foregoing, the violence and damage to the soft tissues being greater. The signs and symptoms are the same as those of a subcoracoid dislocation, but more marked —the shortening especially is greater, and the head can be felt under the skin below the clavicle. The treatment is the same as that of the foregoing variety.

Subglenoid Dislocation. This is considerably less common, as the position of the bones is very unstable; it also is produced by severe abduction of the arm. Most of the clinical features described on pp. 455, 456 are present, while the head of the humerus can be felt in the axilla and the arm will be found to be lengthened, and to be held in abduction. The brachial plexus usually escapes in this variety. Kocher's method of reduction is not specially suitable in this case, and Miller's or Smith's procedures will be found to be better.

The rare variety of this dislocation, **luxatio erecta,** is obvious, as the arm is held vertically above the head and the humeral head can be felt and seen in its abnormal position on the inner wall of the axilla.

Subspinous Dislocation. In many cases of backward dislocation of the shoulder the position of the humeral head is really subacromial rather than subspinous. This injury is usually produced by forcible adduction of the arm, the head of the bone leaving the joint through the back and outer part of the capsule. The clinical features of this dislocation are somewhat different to those of the other varieties, as the arm is held rigidly adducted and slightly flexed and the head of the humerus can be seen and felt at the back of the glenoid, while the whole shoulder is broadened antero-posteriorly and the arm unaltered in length. The best methods of reduction are those of Miller or Smith.

The prognosis as to ultimate recovery of function after dislocation of a shoulder joint is good, provided important nerves are not injured. Scar tissue, adhesions and arthritis sometimes will lead to pain and deficient movement, while recurrent dislocation may occur if abduction movements are permitted too soon.

Unreduced Dislocations. There is a good chance of successful reduction by manipulation under anæsthesia up to six weeks and a fair chance up to eight weeks. After this time it is unwise to attempt it. Consideration must be given to the age and condition of the patient and the amount of function he possesses in his unreduced joint; if it seems that better function is imperative, open operation must be resorted to if the condition has been present more than eight weeks. It is possible either to excise the head, which gives the better result, or to try open reduction, but the latter is often impossible from shortening of the ligaments and muscles. Patients with old-standing unreduced dislocations have often surprisingly good function. After an operation the resulting joint remains weaker than normal and abduction is limited, while osteoarthritic changes occur in the false joint. The golden rule is not to interfere if there is no pain or if sufficient function is present.

Dislocation Complicated by Fracture of the Upper End of the Humerus. In this case, which is by no means uncommon, the dislocation is nearly always of the subcoracoid variety, while the fracture of the humerus may be of the surgical or anatomical neck. The injury is usually produced by direct violence, such as a heavy fall or blow on the shoulder; it is uncertain whether in most instances the fracture or the dislocation occurs first. The condition will resemble a simple dislocation closely, but it should be noticed that in addition to the usual signs of dislocated shoulder (the most important of which consists in feeling the head of the bone in its abnormal situation), there will be crepitus, and the head of the bone does not rotate when the shaft of the humerus is rotated; abnormal mobility of the arm and marked shortening will also be present, whilst shock, bruising and swelling are especially marked. There will also be a certain amount of resemblance to a fracture of the neck of the scapula, but X-ray plates will settle the point.

Treatment. An attempt to reduce the dislocation must be made at once; on no account must the shaft of the humerus be used as a lever to wrench the upper fragment into place, but forcible extension on this fragment in the abducted position may be made, and then it may be possible to manipulate the head of the bone into its socket; the fracture is then treated on the usual lines. If reduction fails, then open operation with excision of the loose fragments gives the best results. Occasionally it may be practicable to peg on the broken portions. In any case the results are usually disappointing, as the condition is commonly met with in the elderly.

After reduction, the condition should be treated as outlined in considering the particular fracture present. The method of allowing the fracture to unite first and then attempting to reduce the dislocation later has nothing to recommend it.

Recurrent Dislocation. Shoulder joints are occasionally seen which are liable to repeated dislocations as the result of very minor injuries or no injury at all. The condition is seen in young women and in epileptics; it is sometimes the result of a previous ordinary dislocation which has not been properly treated, while in other cases it is found that the head of the bone is deformed or deficient or the muscles and capsule unduly lax; these instances are occasionally bilateral. In most cases the pain and disability at the time of the dislocation are very slight, and in other instances where the dislocation occurs frequently on slight or no provocation, it is easily reduced by the patient himself. It thus forms a serious menace to occupational efficiency.

Treatment. Unless contraindicated, operation should be performed. The older operations consisted in pleating the capsule, which is useless, or in ankylosing the shoulder joint; but Clairmont's operation of transplanting a portion of the deltoid muscle, together with its nerve supply, through the quadrilateral space under the head of the humerus is the best. This acts as a sling under the head of the bone, while the deltoid strip contracts and supports the joint during abduction, which is the dangerous movement. If the operation cannot be carried out, abduction should be limited by fixing the upper arm to the side with an apparatus which only allows slight movement.

Other methods, such as Hey Grove's or Henderson's operations, are described in orthopædic text-books.

Minor Injuries of the Shoulder Joint. The mobility of the shoulder joint is so free that sprains are rare, but contusions are common and usually due to direct violence, although occasionally a contusion is produced by injury applied at some distance from the joint. Contusions of the shoulder give rise to a moderate amount of swelling and pain on all movements of the joint in contrast to a sprain, in which only those movements which stretch the damaged ligament are painful. It may be found that after a fall on the hand pain and stiffness occur and persist in the shoulder joint after the original injury has cleared up. This is due to bruising of the articular cartilages in the joint, the so-called "stubbed shoulder," and the resulting arthritis is apt to be persistent and defy treatment. In many cases of direct injury it is only the deltoid muscle and subcutaneous tissues which are bruised, while in other instances the nerves of the brachial plexus or the circumflex nerve are bruised or stretched. This is one of the joints in which manipulation under gas carried to a full range gives very good results (see p. 445).

Another associate of injuries round the shoulder is **Subdeltoid Bursitis,** in which there is persistent tenderness below the acromion, and all efforts at abduction are extremely painful; other movements of the shoulder, however, especially rotation, are painless. This also is very resistant to treatment, and in certain cases recourse has been taken to operation. The anterior part of the deltoid is turned out and down and the bursa excised.

The treatment of these minor injuries consists in applying a sling and giving massage, radiant heat and diathermy locally. If abduction in particular is interfered with, the arm should be supported on an abduction splint.

General Considerations in the Treatment of Shoulder Injuries. As has already been indicated, the chief disability occurring after injuries in this situation is limitation of abduction ; it is, therefore, better in all cases where abduction is obviously interfered with, except dislocations, to treat the case with the arm in abduction either in plaster or upon a metal abduction splint. Adduction always can be regained, but stiffness in abduction is very difficult to correct.

The full range of shoulder movement is present when the patient can pass the hand behind the back with ease and scratch between the shoulder blades or pass the hand to the back of the neck. These form useful exercises to perform in attempting to obtain this range. Another useful exercise consists in instructing the patient to stand facing a wall and to place the hand palm upon it and then gradually climb up the wall with the fingers of that hand, as this regains over-hand movement at the shoulder.

All active movements should be undertaken first in the recumbent position, so that the force of gravity is not acting, later in the erect attitude, the weight of the arm having to be raised, and finally gymnastic exercises with Indian clubs, etc., should be performed.

In treating shoulder injuries in adduction it s a time-honoured fetish to place a pad in the axilla. The upper half of the arm is normally supported by the chest wall, and it is the lower half that diverges from the chest wall and requires supporting. A pad placed in the peak of the axilla may defeat the whole treatment by causing abduction of a short upper fragment. Similarly in a fracture at the extreme upper end of the humerus it is absurd to expect a postero-external splint to have any effect in holding the fragments in good position, as it is impossible by this means to obtain any control of the upper fragment.

FRACTURES OF THE SHAFT OF THE HUMERUS

This includes all fractures between the surgical neck and the epicondyles. These may be transverse or spiral in direction, and are caused by either direct or indirect violence, usually the former; they are often comminuted. Occasionally they may be produced by inco-ordinated muscular action, as in overthrowing a cricket ball; they are most commonly transverse in children and oblique in adults.

The resulting displacement is very variable. Much attention has been directed to whether the fracture is above or below the insertion of the deltoid, as this has an influence on the position of the upper fragment, but this is not as important as has been made out. In nearly all cases the lower fragment is drawn up on the inner side of the upper fragment, but when the fracture has occurred above the deltoid insertion, the pectoralis major, latissimus dorsi and teres major drag the upper fragment in so that it is adducted; if the bone is broken below the insertion of the deltoid, the action of the deltoid muscle in the upper fragment counter-balances the adductor muscles and the upper fragment is then less adducted, or even abducted. The direction of the force and the line of the fracture also have an influence upon the displacement.

All the usual signs of a fracture, *i e.*, shortening, deformity, abnormal mobility, and crepitus, are marked.

The median, ulnar and musculospiral nerves (especially the latter) may be involved in this fracture, and their functions always should be tested as they may be torn, stretched or bruised at the time of the accident or later on be compressed by granulation tissue, callus, or badly applied splints (see pp. 359—368).

Reduction. The routine treatment consists in correcting any deformity by long axis traction, if necessary with a Kirschner wire; the limb should then be fixed in abduction in a plaster or aeroplane splint for three weeks; active movements being indulged in during this period.

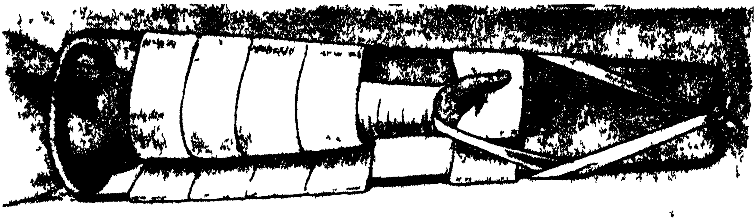


FIG. 229. Thomas's splint for fracture of the shaft of the humerus.

As an alternative treatment a Thomas's arm splint may be applied. This is used as a fixed extension, with the shoulder abducted to a right angle. The extension is fixed to the cross-bar at the end of the splint and counter-extension obtained by the leather ring pressing against the chest wall. The forearm should be supinated and the carrying angle at the elbow maintained by flannel slings (Fig. 229).

If gross deformity still persists open operation must be resorted to. In the case of a pure transverse fracture, impaction alone often will suffice, otherwise plating or grafting will be necessary. Union occurs in adults in from four to six weeks, three to four weeks in children.

Splints may be discarded in three weeks and movements started, proceeding with extra caution in cases subjected to operation; a sling should be retained for a full six weeks and active use commenced at the end of the fourth week. No heavy work should be undertaken before eight weeks at the earliest.

Now consider the case if *expert* massage treatment is available from the first. It is well known that there is no fracture in the body in which we can better afford to neglect the anatomical results for the functional. Again, in those of middle age or over, prolonged or even shortlived immobilisation of the shoulder joint is fraught with much delay in convalescence and even permanent damage. Finally, the chief agent producing displacement is muscular spasm. If we can abolish this and leave the weight of the lower arm as an extending force, the fracture tends to take up good alignment automatically. There is no doubt that in all cases except children the ideal treatment is to use a sling only, commencing full massage at once. At the end of forty-eight hours after massage it will be found that the alignment is much improved. In this connection it must be stressed that the point of the elbow must not be supported by the sling, and after the first forty-eight hours a collar and cuff is preferable. Passive movements of the shoulder can be commenced in ten days and active movements in three weeks.

Results. The results of a fracture of the shaft of the humerus are, speaking generally as regards function, extremely good. Rarely, however, non-union or pseudoarthrosis develops, requiring treatment as given on p. 414 (This is the commonest site for a false joint.) Musculospiral paralysis is seldom if ever complete, and should be treated on expectant lines (see p. 360).

Pathological fracture of the humerus is by no means uncommon in small boys as a result of a bone cyst, often occurring while throwing stones, and also in persons over forty as a result of secondary carcinoma (see pp. 570 and 583). These fractures should be treated as an ordinary simple fracture and sound union often will occur.

Ununited Fractures of the Humerus. If the fracture remains united without the formation of a definite false joint, operation on the lines described on p. 414 will be required. If, however, a definite false joint is present, it should be exposed and the bone ends entering into it completely resected—the bones can then be fixed in position by one of the standard methods described on p. 431.

INJURIES IN THE NEIGHBOURHOOD OF THE ELBOW

The differential diagnosis of these injuries is often difficult on account of the swelling and pain in which they result; moreover, it is also difficult to determine whether movement is taking place in the elbow joint or near it.

These injuries all have a common bearing in the effect they produce upon the range of movement of the elbow joint. It is always possible to regain extension and pronation, but not the converse movements; therefore, all fractures in this neighbourhood, with the exception of fracture of the olecranon, should be treated in full flexion with supination of the forearm. Full flexion is denoted by ability with the forearm supinated to scratch the tip of the shoulder. The radial pulse must be watched carefully, and the flexion lessened if necessary.

FRACTURES OF THE LOWER END OF THE HUMERUS

These include :—

1. Supracondylar fracture.
2. T-shaped fracture involving the joint.
3. Fracture-separation of the whole lower epiphysis.
4. Fracture-separation of the external condyle.
5. Fracture-separation of the internal condyle.
6. Separation of the epicondyles.

If there is much delay before the case comes under observation, accurate diagnosis becomes very difficult from the excessive effusion which always occurs. Note must be taken of the normal carrying angle of the forearm, *i.e.*, in extension the forearm makes an angle outwards of about 15° with the arm. Diminution of this angle is known as *cubitus varus*, increase of it as *cubitus valgus* (p. 710).

All these injuries are especially common in children, when they are usually due either to a fall on the hand or to a fall or blow on the elbow. Either the ulnar or median nerve may be damaged, but luckily these nerve injuries are rare. Interference with the full range of movement in the elbow joint and alteration in the growth of the lower end of the humerus, which may lead to grave changes in the "carrying angle," are not uncommon after these lesions.

The dates of appearance and of union of the various epiphyses in this neighbourhood must be borne in mind, as they shed light on injuries occurring at different ages.

A centre for the main epiphysis, *i.e.*, the external condyle and greater part of the lower end of the bone, appears at three, joins with that for the internal articular facet at sixteen, and unites with the shaft at eighteen. Therefore, below the age of twelve, this is the portion concerned in fracture-separation of the epiphysis. A centre for the internal condyle appears at five, fuses with the rest of the epiphysis about sixteen, and unites with the shaft at about twenty. A centre for the internal epicondyle, that is to say its inner and back half, appears at twelve and unites with the shaft at sixteen. A centre for the external epicondyle appears at fourteen, uniting with the rest at sixteen.

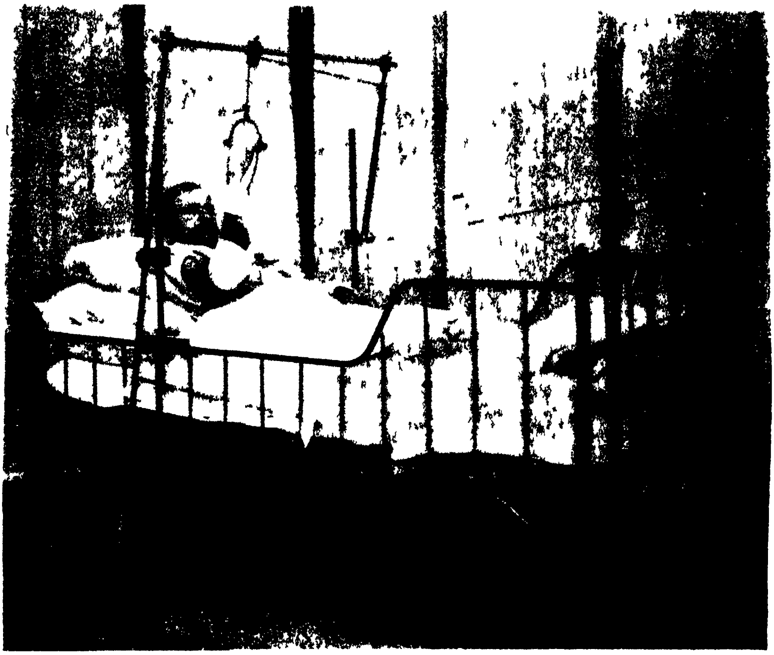


FIG. 230. Fracture of the humerus treated by the extension with Steinman's pin, and with counterpoise adjustment to allow elbow movements (from the clinic of Professor Noordenbos, Amsterdam).

(1) **Supracondylar Fracture.** This is a very common injury in children and is produced as a rule by a fall on the hand, the line of the fracture being downwards and forwards through the olecranon fossa, so that the lower fragment is displaced backwards and upwards, and also usually twisted

backwards as well; the bones of the forearm are also displaced backwards, as they are carried back with the lower humeral fragment. The lower end of the upper fragment projects forwards in front of the elbow joint. This carrying back of the forearm bones will closely resemble a backward dislocation of the elbow joint; it can be distinguished, however, by the fact that the relative positions of the olecranon and internal and external condyles are unaltered (see p. 469).

The forearm is usually held by the other hand at an angle of 120° and semipronated, while the olecranon can be seen projecting backwards; complete flexion is impossible and great swelling rapidly occurs—abnormal mobility can be detected just above the joint (especially in a lateral direction), while crepitus is often present. The lower end of the upper fragment sometimes pierces the skin in front of the joint and makes the fracture compound. Shortening of the arm (from the shoulder to the wrist) is present, but the distance between the external or internal condyle and the wrist is unaltered.

Reduction should be effected as soon as possible. A general anæsthetic is given and the upper arm steadied by an assistant, while the forearm is grasped, pronated and hyper-extended, allowance being made for the carrying angle. Strong long-axis traction is applied and the elbow is then flexed, pushing the upper fragment backwards with the thumb and the olecranon forward with the fingers. Successful reduction is indicated by the ease with which flexion, previously unobtainable, can be obtained.

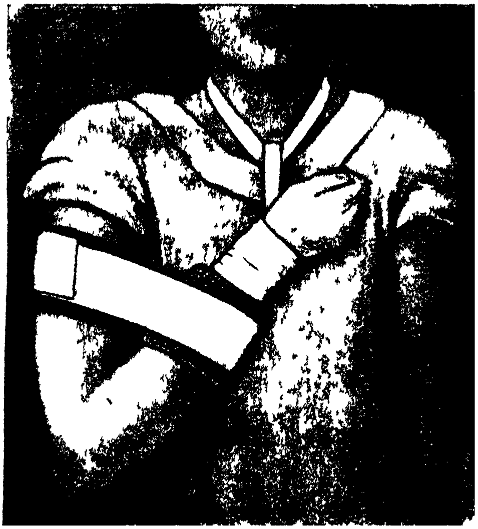


FIG. 231. Collar and cuff sling.

Other cases occur (often those in which the lower fragment has come forward) where good position can be maintained only with the arm in extension. In these cases no hesitation should be had in fixing the arm in extension in plaster of Paris, rather than proceeding to open operation.

If difficulty in reduction occurs the insertion of a Kirschner's wire or Steinman's pin above the olecranon with suitable extension will allow replacement of the fragments, and save an open operation. It will allow movement of the joint and prevent the formation of adhesions.

If, owing to delay, reduction cannot be effected by prolonged traction, it must be carried out by open operation. Should operation be required a vertical incision is made, splitting the triceps, and the fragment levered into position. The forearm is then put up in flexion and pronation, so as to keep the pronator radii teres relaxed. Reduction should always be checked by X-ray examination.

Treatment. The forearm must now be fixed in flexion and supination, as in this case the triceps muscle will act as a natural splint. This may be done in several ways: (1) A loop of adhesive plaster is passed round the wrist and arm over padding (Fig. 231) and the wrist slung in a collar and cuff. This is the best method. (2) A plaster may be employed incorporating a U-shaped plaster strip or a moulded metal bar round the back and sides of the elbow (Fig. 232).

As regards the degree of flexion, this must not be great enough to interfere with the circulation as evidenced by diminution of the radial pulse and by œdema of the hand. If these occur, the forearm must be lowered promptly until the circulation is adequate. The radial pulse and hand should at all times be left accessible to examination, and examined frequently in the first forty-eight hours. After this time it often will be found that the forearm can be flexed still further.

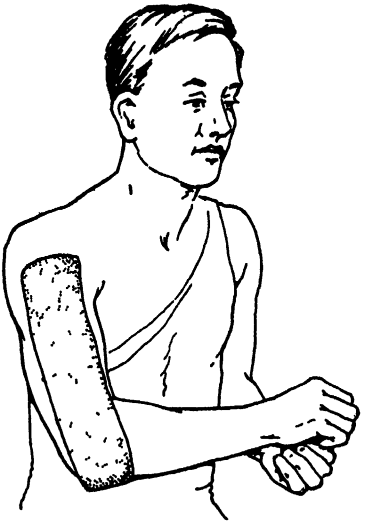


Fig. 232 Plaster of Paris splint for fractures of the shaft and lower end of humerus.

With regard to after treatment, the best standard method is the maintenance of fixation in full flexion or extension for three weeks. No movements at the elbow of any kind are permitted during this time, although the fingers, wrist, and shoulder should be used from the start. At the end of three weeks the wrist is lowered a little every day, the right angle being reached by the end of the fourth week. The collar and cuff should be retained from six to eight weeks; if it be found at any time that as the result of lowering the forearm full flexion no longer can be obtained, then the forearm must be flexed as far as possible and maintained in this position for several days When full flexion is again possible gradual lowering may be recommenced.

Massage apart from movement may be given from the start, but in children, who form the bulk of the patients, it is quite unnecessary, while too early movement and massage may give rise to excess of callus or myositis ossificans which will limit joint movements, especially flexion.

Results are as a rule extremely good, especially in children. Some difficulty, however, may be experienced in regaining complete extension at the elbow joint and as much as eight months may pass before this is possible. It can be encouraged by vigorous exercises in the later stages or the attachment of a heavy plaster bangle to the wrist and the application of a splint at night.

Occasionally irregular growth occurs from premature synostosis.

(2) **T-Shaped Fracture.** This consists in a supracondylar fracture with a crack running between and separating the two condyles; this crack necessarily enters the elbow joint. The causes are exactly similar to the above, but it usually occurs in adults as the result of severe violence, so that the fragments may be comminuted. The signs are those of a supracondylar fracture, while in addition the two condyles can be moved upon each other, and the joint is full of blood. Much coarse crepitus is present. Treatment is the same, but if good alignment of the fragments cannot be obtained by manipulation, it will be necessary to peg or screw them together. This however should be avoided, if possible, as the results are not good.

(3) **Fracture-Separation of the whole Lower Epiphysis.** This is most common in children under six, but will be seen up to the age of fourteen. Occasionally it is a pure epiphyseal separation, but it is more commonly found that a small portion of the diaphysis is broken off also; it is the result of injuries similar to those which cause a supracondylar fracture, which it closely resembles, in that the epiphysis is usually displaced backwards: there may be the same difficulty in distinguishing it from a backward dislocation of the elbow joint. Occasionally the periosteum is not torn, and then there is very little displacement. Union takes place in three weeks and the treatment is the same as that of the supracondylar fracture (see p. 464). Interference with the growth of the bone is not uncommon after this lesion.

(4) **Fracture-Separation of the Outer Condyle** is usually seen in children under twelve. It is more frequently injured than the inner condyle, the line of fracture being partly within and partly outside the joint; the fragment is usually displaced outwards and forwards, and is rotated considerably. Pain, crepitus and mobility of the fragment will be present, while the carrying angle of the arm will be altered, at first as the result of the displacement, and later permanently from irregular epiphyseal growth; this will lead to cubitus varus or valgus, and at times a delayed ulnar nerve palsy.

Treatment is carried out as indicated for (1), but if manipulation fails, as is usually the case if any gross displacement has occurred, open reduction by splitting the triceps and levering back the loose fragment must be tried. Occasionally the displacement is so extreme that the fragment pierces the skin.

(5) **Fracture-Separation of the Internal Condyle** is rare and is dealt with as described under (1).

(6) **Fractures of the Epicondyles** are usually met with in the form of sprain-fractures, small portions of the bone being pulled off by the muscles attached to them. In the external condyle the lesion is very rare, but occasionally the internal epicondyle is knocked off by direct violence and is displaced downwards and forwards, where it can be felt moving upon the shaft of the bone; in this case the ulnar nerve is liable to be injured, either primarily or later by callus. If displaced into the joint removal by open operation is indicated.

Union is often fibrous and the treatment is carried out as in (1).

Complications of Fractures of the Lower End of the Humerus.

(1) *Volkmann's Ischæmic Contracture.* This is due to necrobiosis of the flexor muscles from diminished blood supply, due to excessive flexion of the forearm or from tight splints or bandaging. It should never occur, but it must be remembered that interference with the circulation for even a short time may produce it (p. 410).

(2) *Myositis Ossificans.* This occurs especially after dislocation of the elbow with sprain-fracture of the coronoid process, but it may occur after any injury in the region of the elbow. Immobilisation is the only treatment. All efforts at movement or operative removal merely increase the output of bony tissue.

(3) *Diminution of Movement at the Elbow.* This, as hinted above, is due to too early and excessive movement. The treatment consists in absolute rest, when the range of movement ultimately will be regained.

(4) *Ankylosis of the Joint*—complete or partial. This is not likely to occur if reduction has been properly performed and after-treatment has been correct. It may need operative treatment for its relief (see p. 730).

FRACTURES OF THE UPPER END OF THE ULNA

(1) Fracture of the Olecranon. This is a common injury usually seen in adults; it may be caused either by direct violence, in which case it follows a heavy fall on the elbow and is usually comminuted, or by muscular action. In either case the general direction of the fracture is transverse, while it usually runs through the process; it involves the elbow joint, which becomes filled with blood and exudate, so that the amount of pain, swelling and bruising are very marked. In spite of its superficial position, the fracture is rarely compound. Deformity, in the nature of separation, may or may not be present, this depending upon the level of the fracture and the condition of the triceps tendon and the periosteum. If separation has occurred a distinct sulcus is palpable, and the gap between the fragments will be felt to increase on flexing and diminish on extending the elbow joint.

Treatment. (1) *Without Separation.* The arm should be placed in a sling with the forearm flexed to a right angle and massage commenced from the start, as this abolishes spasm of the triceps and promotes absorption of exudate. Active movements of the fingers, wrist and shoulder may be commenced at once. Passive movements of the elbow, holding the olecranon in contact with the shaft of the bone with the finger, may be commenced at the end of a week, and active movements at the end of a fortnight. The sling may be discarded in four weeks, but no heavy work should be undertaken for six weeks at least.

(2) *When Separation is Present.* The best result is obtained by open operation, turning up a flap of skin, and either suturing the torn aponeurosis or wiring the two fragments together, while the opportunity is taken of clearing all blood clot out of the joint. Suture of the aponeurosis is the better treatment, as firm fibrous union results, giving a functionally powerful arm. After operation the arm is immobilised in a sling, movements may be commenced after the removal of the stitches and the sling may be discarded at the end of three weeks. Active movements of the other joints of the limb may be commenced at once, but a sling should be worn with the forearm at a right angle. If operation is refused or considered inadvisable, the fragments should be approximated by adhesive plaster, massage commenced at once, and the arm treated on a splint in complete extension in an exactly similar manner to that described above. No heavy work should be allowed for two months.

Results. If complete apposition is achieved, the union may be bony, but in most cases fibrous union is the result. Provided overstretching of the young fibrous tissue is prevented, the functional result is good, the arm being as strong as it was before the injury. Occasionally the upper fragment becomes adherent to the lower end of the humerus and causes much disability.

Old Malunited Fractures of the Olecranon. In cases where union has not occurred properly it is sometimes found months or years afterwards that the fragments are widely separated, owing to the pull of the triceps muscle; at times they are 3 or 4 inches apart and connected by a strong fibrous band. In most of these cases the function of the arm is surprisingly good, and little treatment is required. Operation performed in the endeavour to bring these fragments together will be very difficult, as it is not at all easy to bring the upper fragment down, owing to the contraction and shortening of the triceps.

Separation of the Olecranon Epiphysis. Disruption of this scale-like epiphysis is a very rare injury indeed; its symptoms, signs and treatment are the same as those of a fractured olecranon.

Fracture of the Coronoid Process. This fracture rarely occurs by itself, but usually is seen as a complication of a posterior dislocation of the elbow, the process being torn off with the brachialis tendon; the wide attachment of this muscle, however, prevents much displacement. Its presence is suspected if the dislocation recurs readily after reduction, but the fracture only can be diagnosed for certain by means of an X-ray picture.

The treatment is identical to that of a supracondylar fracture of the humerus (q.v.). There is special risk of myositis ossificans caused by injudicious haste in moving the elbow joint. Full use of the arm may be allowed in two months in an uncomplicated case.

Fracture of the Upper Third of the Shaft of the Ulna. This is a rare injury. If the radius remains intact it is unusual for any degree of displacement to occur. The injury is almost always due to a direct blow upon the posterior border of the ulna, and is therefore quite commonly compound. The condition can usually be diagnosed in the absence of displacement by running the finger down the posterior border of the ulna, when a very tender local spot, surrounded by swelling and bruising, will be felt.

The *treatment* consists in applying a posterior splint from the tip of the olecranon to the heads of the metacarpals, with the arm slung at a right angle. Massage may be commenced at once, passive movements of the elbow on the tenth day, and active at the end of three weeks. The splint may be discarded at the end of three weeks, the sling at the end of four. The functional results are good, though non-union is not uncommon.

Fracture of the Upper Third of the Ulna and Dislocation of the Head of the Radius. This is a much more common injury and is usually produced by direct violence acting upon the ulnar border; there is a tendency for anterior angulation at the site of fracture. The head of the radius is palpable in its abnormal situation; pronation and supination are interfered with.

Reduction is effected by manipulation and extension and the fracture treated in full flexion and supination, otherwise exactly as outlined for a supracondylar fracture. A short splint for the back of the forearm may be incorporated.

In an old-standing case with limitation of flexion it may be advisable to excise the head of the radius.

FRACTURES OF THE UPPER END OF THE RADIUS

(1) **Avulsion of the Tubercle.** This is occasionally produced by forcible action of the biceps.

(2) **Fracture of the Head.** This is usually due to direct violence, and the line of fracture is vertical and entirely intracapsular. Displacement may or may not be present. If it is, the inner fragment is usually displaced forwards and inwards, thus limiting flexion and supination. The condition often accompanies a dislocation of the elbow or a fracture of the ulna. There is localised pain and crepitus, marked interference with pronation and supination, while extension, and possibly flexion, may be free; the displaced fragment can often be felt, possibly moving on supination and pronation.

Treatment. If displacement has occurred, open operation should be carried out and the loose fragment removed, or the whole head proximal to the orbicular ligament excised. The after-treatment is the same as in a case not subjected to operation.

If there is no displacement, the forearm should be immobilised in full flexion with supination.

Results. In those of advancing years traumatic osteoarthritis is prone to develop; otherwise the results are good. Union is generally satisfactory.

(3) **Fracture of the Neck.** This is rare. Displacement is generally absent, as the orbicular ligament remains intact. If displacement is present the head should be excised. Speaking generally, treatment is similar to that for fracture of the head. **Separation of the upper radial epiphysis** is occasionally seen before the seventeenth year.

DISLOCATION OF THE ELBOW JOINT

This is most often seen in young adults and is the commonest dislocation met with in the young. Both bones may be dislocated:—

1. Backwards and slightly inwards, the common type.
2. Forwards.
3. Laterally, in which case the dislocation is in the nature of a subluxation.

(1) **Posterior Dislocation.** This is produced as a rule by a fall on the outstretched hand, and if seen early diagnosis is easy, but swelling and effusion rapidly supervene. There is a characteristic slackness of the triceps tendon and hollowing above the olecranon; the distance from the external epicondyle to the radial styloid is reduced by about an inch, while the distance from the acromion to the epicondyle remains the same, in exact contradistinction to the measurements which obtain in a supracondylar fracture of the humerus (Fig. 233). All movements are stiff and limited, and there is a characteristic rubbery rebound. The coronoid process may be fractured as well (q.v.), while in many cases this dislocation is incomplete. All the ligaments of the joint are torn, while the coronoid process, if not fractured, lies behind the humerus in the olecranon fossa, the condyles of the humerus being unaltered. The biceps tendon is tightly stretched over the lower end of the humerus, while the brachialis anticus tendon, the median or ulnar nerves may be torn. It is as a result of this injury that the formation of masses of bone in front of the elbow in the neighbourhood of the brachialis anticus muscle is not infrequently seen; these are due probably to certain bone-forming cells being pulled off the bone.

In this injury the tip of the elbow and the forearm appear to be displaced backwards, as is also the case in a supracondylar fracture of the humerus; it can be noticed, however, that the relation of the three points formed by the two condyles and the olecranon is altered, the latter being displaced backwards; these bony points are not altered in a fracture of the humerus. The elbow is usually held flexed at about 130 degrees, while great pain is present; the rapid swelling soon will obscure the bony points.

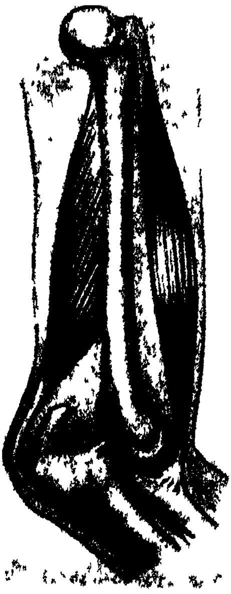


FIG. 233. Posterior dislocation of the elbow.

Treatment. Reduction is easy, being effected often without anæsthesia. The surgeon places his knee in the angle of the elbow, pressing back the lower end of the humerus while pulling forward and flexing the forearm.

Reduction occurs with a characteristic click, and there is little tendency to recurrence unless the coronoid is fractured. The arm is placed in a sling with flexion to forty degrees and light massage commenced at once. If the coronoid process is fractured flexion should be more complete and extension movements delayed. Passive movements may be started after five days and active movements after fourteen. The sling is discarded in three weeks, but no heavy work should be allowed for six.

In old-standing dislocations reduction by manipulation may succeed up to one month from the time of injury; otherwise, and in cases where there has also been a fracture, open reduction will have to be carried out. Should an excessive formation of bone occur in front of the joint, it will be found that about four to six weeks after reduction the movements become restricted again and a hard mass can be felt; with absolute rest reabsorption of this mass may be expected in about six months.

(2) **Anterior Dislocation** is rare unless the olecranon is fractured as well: it is often incomplete. Lengthening of the forearm as measured from the external epicondyle to the radial styloid is present, while the elbow is flattened at the back and held flexed; the condyles are prominent behind. After reduction by traction, the treatment is as given above.

(3) **Lateral Subluxations** are rare apart from associated fractures. Both inward and outward dislocations are always incomplete; the inward form is the less rare and is due to falls on the hand when it is in abduction. The bony points are easily palpated and diagnosis is simple.

Dislocation of the Ulna Alone. Very occasionally posterior dislocation occurs without other damage; but in most instances the internal condyle is fractured. The treatment is similar to that of posterior dislocation of both bones.

Dislocation of the Radius Alone. Posterior and lateral dislocations are rare, but anterior dislocation is fairly common, often in conjunction with a fracture of the upper third of the ulna and always associated with tearing of the orbicular ligament (see p. 469). It may be produced by direct violence, applied from behind, or by falls on the hand with the forearm fully pronated, the displaced head passing into the capitellum. There is gross limitation of flexion and the head of the bone is palpable in its abnormal situation, where it can be felt to rotate. Movements of supination and pronation are limited and painful, while the forearm is held partly flexed and pronated. There will be a depression behind where the head of the bone should be, and slight shortening of the radial side of the forearm.

Treatment consists in reduction by traction and manipulation. Full flexion and supination must be maintained, and the joint be fixed in this position, otherwise the deformity will recur, owing to tearing of the orbicular ligament. No active movements should be permitted for four weeks. In old-standing cases the head of the radius should be excised.

In this injury the posterior interosseous nerve is liable to be damaged, either by tearing or by pressure.

Pulled Elbow (Radial Subluxation). This is a common injury in young children and is produced by pulling up a child by the forearm. The result is that the front part of the radial head slips partially through the orbicular ligament. Flexion, pronation and supination are all interfered with; a click is felt at the time of the injury and the child complains of pain and holds the arm midway between pronation and supination and slightly flexed. There is no noticeable deformity.

Treatment consists in reduction by flexing and alternately pronating and supinating the forearm; this takes place spontaneously at times. After-treatment is unnecessary.

Sprains of the Elbow. These are not rare, and sprain-fractures, affecting the epicondyles of the humerus, are fairly common. The ligament damaged will be tender with a swelling around it, but there is no alteration in the bony points.

Tennis elbow is an injury of this type; in one form of this condition there is a persistent point of tenderness over the external condyle, with occasionally inexplicable loss of power in the forearm. Osgood states that it is due to inflammation of a small bursa in this situation and advises excision. Another form of "tennis elbow," which is also seen in rowing men, consists in a strain of the insertion of the pronator radii teres.

Certain cases are cured by fully pronating and flexing the forearm under gas.

Fractures of the Shaft of the Ulna. These resemble in causation and treatment fractures in the upper third of the shaft (q.v.); the deformity is usually to be detected by running the hand along the subcutaneous border, when at least a painful localised hæmatoma will be palpable. It is important to remember, however, that in a fracture of the lower third of the shaft treatment should be more prolonged, as union is slower in this situation.

Fractures of the Shaft of the Radius. These are usually due to direct violence and are transverse in direction. In other cases they are caused by indirect violence such as falls on the hand or efforts at pronation against resistance. The type of displacement depends on whether the fracture is above or below the insertion of the pronator teres. If above this point the upper fragment is flexed, supinated and adducted by the biceps and supinators, while the lower fragment is pronated and drawn towards the ulna. If the fracture is below this point the upper fragment will be flexed slightly and pronated, while the position of the lower fragment will depend upon the violence causing the injury; it is usually drawn towards the ulna.

In this fracture the signs and symptoms may be very slight and the fracture may not be noted until an X-ray photograph is taken. There is loss of, and pain on attempting, pronation and supination, and in most cases the head of the radius can be felt not to rotate with the shaft.

Treatment. Reduction should be effected by manipulation and long axis traction, counter-extension being secured by a linen band around the lower part of the arm (Böhler). If it fails open operation, with impaction or pegging, should be undertaken. If the fracture is of the greenstick variety, as is often the case in young patients, it should be straightened forcibly, the fracture being completed if necessary. In fractures of the lower third of this bone, reduction may be interfered with by the tendons of the abductor longus pollicis and the flexor brevis pollicis slipping between the fragments so that open operation will be required, though traction with the forearm supinated and the thumb abducted so that the muscles are cleared from the fracture should be well tried before operation is resorted to.

After reduction the forearm should be fixed in extension and full supination on a plaster of Paris splint, extending from the middle of the arm to the heads of the metacarpals and being bent opposite the elbow, to allow of the carrying angle.

Active movements of the shoulder and fingers must be used from the first. Union is often slow and the plaster may need to be retained as long as two months, though in young patients it may be less. Union must be checked by X-ray pictures and the limb can be used as soon as the splint is discarded if union is then found to be firm.

Undue tightness of the splints must be guarded against continually, otherwise Volkmann's ischæmic contracture may supervene (see p. 466).

Fracture of the Shafts of the Radius and of the Ulna. This is one of the commonest fractures met with; in children it is often of the greenstick variety. For perfect functional result, perfect anatomical result, especially in the case of the radius, is essential, and the risk of cross union must always be borne in mind. The fracture may be due to direct or indirect violence, such as direct blows, bending of the forearm or falls on the hand. In the first case the line of the fracture tends to be transverse; in the latter it tends to be spiral and occurs at a different level in each bone. In the case of the ulna it is at the junction of the upper and middle thirds, and in the case of the radius at the junction of the lower and middle thirds.

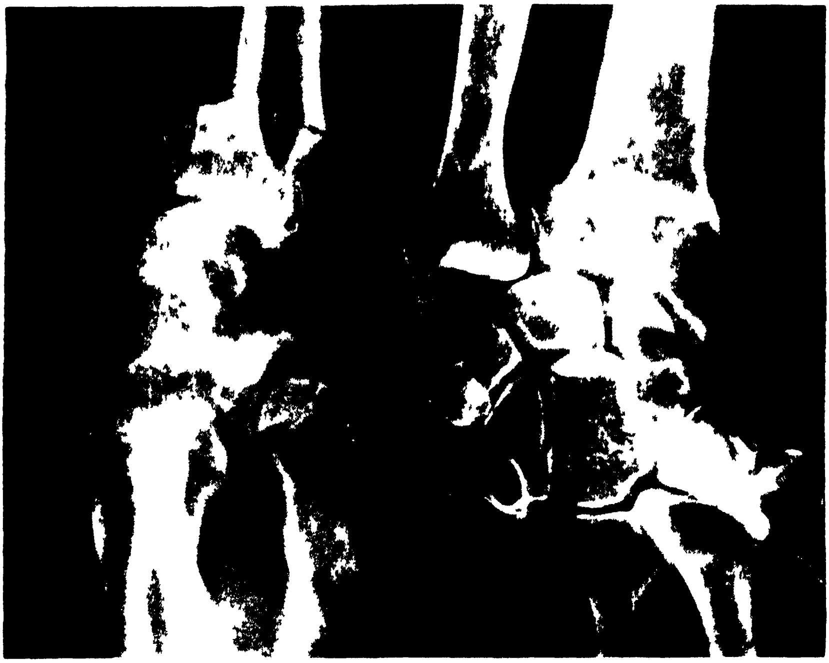
There is usually obvious angular deformity, with pain and swelling of the forearm, which the patient supports with the opposite hand. Occasionally the effusion may interfere with the radial and ulnar pulses, and in these cases tension needs prompt relief by incision through the deep fascia, or Volkman's contracture will supervene.

The displacement depends upon the force, the level of the fracture and the muscles in action; it tends to be well marked, the ulna being angled backwards and the radius forwards. In addition the upper radial fragment is, as a rule, adducted and supinated, the lower pronated. This holds good, whether the fracture be above or below the pronator insertion. In many cases both bones are angled to one or other side, while in other instances all four broken ends converge and more or less meet at one spot. Thus shortening may be quite marked.

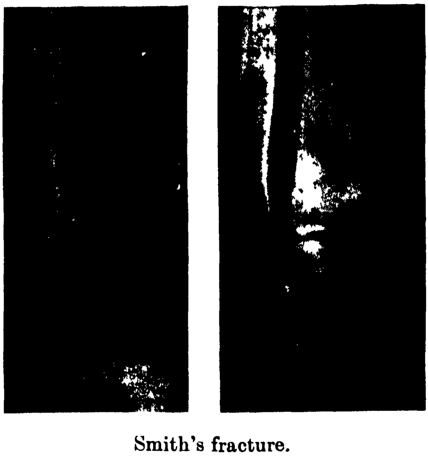
Treatment. Reduction must be attempted by powerful long-axis traction under an anæsthetic with counter-extension by a band round the lower arm, but if gross displacement is present it usually fails and then extension by Kirschner wires must be used. When applying the plaster case it is wise to pad between the bones, by adhesive rubber or felt, so that danger of cross-union may be minimised. If good anatomical position, as evidenced by an X-ray examination in two planes, cannot be effected in this way, open reduction must be undertaken. When considering operation, we may hesitate in the case of the very young, as we can allow more laxity in our idea of perfect reduction; for in the young (*i.e.*, under fifteen) a bone which is quite markedly bent will grow straight and a certain amount of shortening will also set itself right in time. At operation, fixation of the fragments is obtained, preferably by simple impaction; failing this, in a spiral or oblique fracture, by pegs, plates or a lashing of catgut or kangaroo tendon. If operation is undertaken it is the radius upon which interest must be concentrated, for if the position of the radius is perfect, slight displacement of the ulna may be neglected. After reduction, splintage is carried out exactly as outlined for fracture of the radius with displacement, save that, as there are grave risks of refracture, the splints, if necessary, should be retained for more than two months. Active movements should be permitted at once and no work undertaken for two weeks after removal of the plaster. Any splints employed in treating this fracture must be wide, at least one inch wider than the forearm, so as to overlap it on either side; by this means compression of the forearm from side to side by the bandages is avoided, with its risks of cross union.

The prognosis in this fracture should be guarded, as the movements of pronation and supination may be interfered with if deformity persists or there is an excess of callus.

PLATE III.



Colles's fracture



Smith's fracture.

To face p. 473.

Non-union and the formation of a false joint occur occasionally in this situation, especially in children, while Volkmann's ischæmic contracture is liable to occur. Cases of gangrene of the hand have been described after this injury, but probably these are due to badly applied and too tight splints and bandages, rather than to the fracture or damage associated with it.

Should mal-union or cross-union occur, operation will be necessary, and it may be very difficult. The bones must be chiselled apart, reset in proper position, and fixed there by some form of internal splintage (see p. 431) if necessary.

Non-union of this fracture must be treated by the methods described on p. 414 ; again the radius must receive most attention.

INJURIES OF THE WRIST AND HAND

Fractures of the Lower End of the Radius and of the Ulna.

1. Colles's fracture, with or without fracture of the ulnar styloid.
2. Compression-fracture of the lower end of the radius.
3. Fracture of the radial styloid.
4. Smith's fracture or reversed Colles's fracture.
5. Separation of the lower epiphysis of the radius, with or without separation of the ulnar epiphysis or ulnar styloid.
6. Fracture of the ulnar styloid.

In all these fractures the damage to the wrist joint and surrounding ligaments and tendons is of the gravest importance, and it is common for troublesome arthritis and teno-synovitis to develop after these injuries. An X-ray film (stereoscopic, if possible) always should be taken, otherwise minor injuries of the carpus are liable to escape detection. These fractures are frequently impacted, so that they may show in one plane only.

(1) **Colles's Fracture.** This is one of the commonest fractures and is most commonly met with in middle-aged females. It is produced by a fall on the palm of the outstretched hand when nearly fully pronated, the force being transmitted through the ball of the thumb. The line of fracture is roughly transverse, but occasionally there is comminution with involvement of the wrist joint, while the inferior radio-ulnar joint is liable to extensive damage also. The lower fragment is displaced backwards, outwards and upwards, and rotated backwards, so that the normal joint-line of the wrist is upset. As a result of the outward displacement, the internal lateral ligament is torn or the ulnar styloid fractured. Very frequently the fragments are impacted. The fracture runs through the cancellous bone at the end of the radius and is within three-quarters of an inch of its articular surface. It is usually found that the periosteum and soft tissues are far more damaged on the front of the wrist than on the back.

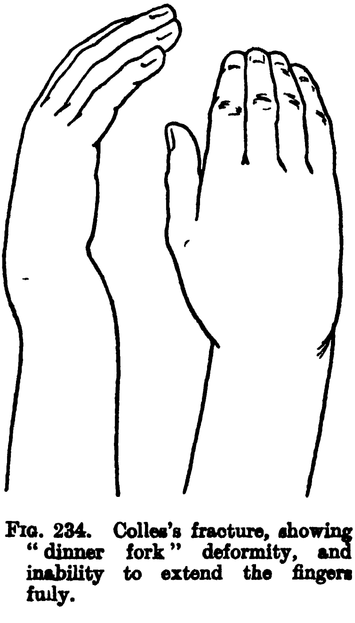


Fig. 234. Colles's fracture, showing "dinner fork" deformity, and inability to extend the fingers fully.

Clinically the fracture is usually obvious, as the hand and wrist take up a position which, when seen from the side, resembles a dinner fork, the distal fragment forming a prominence at the lower part of the back of the wrist, and the hand then flexing forwards again below. The wrist is broadened from side to side and the fingers are held flexed as the flexor tendons are drawn taut over the lower end of the upper fragment. In addition to this, it can be seen that the hand and wrist are carried bodily towards the radial side, while the radial styloid will be found to be as high or higher than the ulnar styloid ; this latter process, with the whole lower end of the ulna, is unduly prominent. Bruising and swelling of the soft tissues are often very slight, but pain is severe. Pronation and supination are lost, but crepitus is often absent, and no attempt must be made to elicit it. If the ulnar styloid is fractured there will be tenderness over it, but this tenderness is often present and due to tearing of the internal lateral ligament. Flexion and extension are both limited, especially the former.

Treatment. Perfect reduction is of the greatest importance if function is to be preserved, and this may be effected by one of two standard methods. Nitrous oxide anæsthesia is usually sufficient.

1. In the case of the right hand the surgeon grasps it with his right as if shaking hands, and with his left grasps the patient's wrist, his thumb being on the lower fragment, his fingers at the front of the wrist on the upper fragment. The deformity is first exaggerated to produce disimpaction ; long axis traction and ulnar deviation are then carried out and the fragments moulded into position with the left hand. Reduction is checked by the position of the radial styloid, by palpation, by the increased range of movement at the wrist, and by an X-ray photograph (Plate III.).

2. Robert Jones's method.

To reduce a left Colles's fracture the surgeon takes the patient's left arm in his left hand, with his own scaphoid tubercle against the projecting lower edge of the shaft. He then places his right hand on the back of the patient's wrist, with his own scaphoid on the projecting lower fragment. A firm grip, with slight traction, and a twist of the wrist reduce the deformity completely.

Reduction can be effected with more or less ease by these methods up to the fourteenth day, after which it will be necessary to use a Thomas's wrench. It is usual after reduction for the fragments to impact in their new position, but occasionally, particularly in the elderly, they remain mobile or displace readily, requiring special vigilance in treatment. With regard to the necessity for reduction, it may be stated that in all save the very old and decrepit, if impaction is not in perfect position, reduction should be carried out. In the case of the old, as the functional result is never very good, it is wiser to concentrate on the functional rather than the anatomical result.

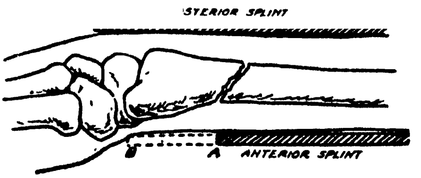


FIG. 235. Diagram of the principles of splintage for Colles's fracture.

3. Böhler's method.

In this method a bandage is attached to the ring and little fingers, also to the thumb, index and middle fingers by some adhesive such as masticol, and steady traction is made on these with the middle and ring fingers widely abducted, and at the same time the fragments are manipulated and the wrist flexed Counter-extension is applied by means of a bandage or towel passed round the arm just above the elbow This method gives excellent results, but necessitates the help of one, or better still two assistants, and is therefore seldom suited to general practice.

Fixation may be effected in numerous ways The following may be taken as a useful standard method —

After reduction, the limb is fixed in plaster of Paris as shown in Fig. 236, but the wrist is slightly plantar and never dorsiflexed Care must be taken, that the proximal phalanges can be fully flexed by the patient, and if necessary the end of the plaster must be cut away to permit this This splint should be retained until firm union has occurred—usually from three weeks to a month—and in the meantime the patient can exercise all the joints of the limb, especially the metacarpal, phalangeal and interphalangeal joints, indeed, the hand can be used for practically any purpose

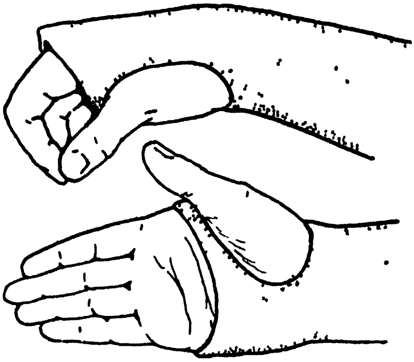


Fig 236 Plaster of Paris splint for Colles s fracture

After removal of the plaster, full use of the forearm can be permitted, and physical methods can be used when necessary to encourage free movements of the wrist.

The old-fashioned Carr's splint, though useful for first-aid fixation, does not control the lower fragment sufficiently to give a good result if used to secure permanent fixation of the fracture

Fig. 237 "Cook-up" plaster.

After three weeks the splint is discarded and the wrist strapped for support for a few days, and full use of the wrist is permitted in six weeks. This applies to cases where reduction has been perfect, in which case the functional result should be perfect.

(2) **Compression-fracture of the Lower End of the Radius.** This is produced by a backfire when starting up a car or by falls on the wrist. It is impacted and generally comminuted. The fracture usually occurs an inch or two higher up the shaft than does Colles's fracture, and then there is a tendency for forward angulation to occur. Other structures in the carpus or metacarpus may be injured at the same time, and much bruising is present always. Severe displacement is uncommon, and consequently clinically it appears as a severe sprain of the wrist joint.

Treatment. Reduction, if necessary, is carried out in a similar manner to Colles's fracture. Fixation is maintained for three weeks, preferably in a plaster, with full dorsiflexion at the wrist joint. The plaster should extend down to, but not beyond, the heads of the metacarpals, leaving the metacarpophalangeal joints free (Fig. 236). The fingers are moved from the start, and electrical treatment given to the forearm muscles, but the wrist should remain fixed absolutely for three weeks. After this the plaster is bivalved, half of it used as a gutter splint, and massage and mobilisation of the wrist commenced. The splint may be discarded in four weeks and the sling in five, while full use of the wrist is permitted in six weeks. Unless there is severe associated injury involving the joint and leading to fibrous adhesions, the functional results should be perfect. If preferred a metal cock-up splint may be utilised.

The method described above gives more reliable results than treatment by immediate mobilisation and, if the wrist is kept dorsiflexed, flexion always can be regained.

(3) **Fracture of the Radial Styloid** is in reality a mild degree of (2). Deformity is, as a rule, absent, and impaction present, the cause, treatment and results being similar. In certain cases function may be permitted earlier, that is to say, after fourteen days' splintage. The wrist is then strapped and full movements commenced. Either of these last two fractures are common in chauffeurs from backfires (**Chauffeur's Fracture**).

(4) **Smith's Fracture.** This fracture is the reverse of Colles's fracture and consists in a break of the lower end of the radius, with the lower fragment displaced forwards (Plate III.). It is usually transverse and due to severe flexion of the wrist, as occurs in heavy falls upon the back of the hand. On the back of the wrist the head of the ulna and the lower end of the upper fragment of the radius can be seen and felt to project, while there is a prominence on the front of the wrist due to the lower fragment, the whole hand being abducted towards the radial side ; as in the case of Colles's fracture, the radial styloid will be found at the same level as or above the ulnar styloid. The fracture in some ways may resemble a dislocation of the wrist. The treatment is the same as in the case of Colles's fracture, the necessary manipulations being reversed.

(5) **Separation of the Lower Epiphysis of the Radius,** with or without fracture of the ulnar styloid or separation of the ulnar epiphysis. This epiphysis lies outside the synovial membrane of the wrist joint ; it is frequently separated in patients under the age of eighteen, the injury being produced in the same manner as Colles's fracture in the adult. It closely resembles Colles's fracture, except that the line of fracture is more accurately transverse, while the abduction and backward rotation of the hand are less marked ; muffled crepitus usually can be obtained. Perfect reduction always should be aimed at, and is usually obtained easily. After this, treatment and after-treatment are similar to those of Colles's fracture with

perfect reduction. A perfect result is the rule, but occasionally from premature synostosis, the radius stops growing, while the ulna, continuing to do so, pushes the whole hand to the radial side (see p. 402). In this case resection of the ulna may be required later on. This epiphyseal separation is often accompanied by fracture of the shaft, or of the styloid process of the ulna or dislocation of the radio-ulnar joint. It is sometimes compound.

(6) **Fracture of the Ulnar Styloid.** This seldom occurs alone and is associated usually with one of the above injuries, in which case its treatment is incidental. If it occurs alone the wrist should be strapped for fourteen days and the arm carried in a sling for three weeks.

(7) **Separation of the Lower Ulnar Epiphysis.** This is a rare njury, which may lead to arrested growth of the ulna and ulnar deviation of the hand. Its treatment is the same as in the case of radial epiphyseal separation.

DISLOCATIONS OF THE WRIST AND CARPAL JOINTS

Dislocations occur at the radio-ulnar, radio-carpal and in the carpal joints, but owing to the strong ligaments and the free movements they are all rare.

(*a*) **Radio-carpal Joint.** These dislocations may be either posterior, that is to say the hand passes backwards, the commoner type of a rare injury ; or anterior, the hand passing forward ; in either case the ligaments are torn and the tendons displaced, while the articular surface of the radius may be chipped. The styloid processes retain their normal relations ; though at first sight the deformity resembles Colles's fracture, it should be noticed that the deformity lies at a lower level. Occasionally the styloid processes are fractured also. Either variety is usually due to severe violence, such as a heavy fall on the wrist ; in both the hand is held flexed, the palm is shortened, but the forearm is unaltered in length.

Treatment. Reduction is carried out by traction and usually proves easy. The wrist should be immobilised in dorsiflexion in a plaster gutter or a metal splint and massage ; full finger movements should be commenced at once. The splint may be discarded in fourteen days and the wrist strapped for a further fourteen days. Passive movements may be commenced after five days, and active movements at the end of fourteen. Use of the wrist for light work is permissible in four weeks, for heavy work in six.

If a fracture involving the joint surface complicates the case, the wrist should be immobilised in plaster for twenty-one days (see compression-fracture of the lower end of the radius).

(*b*) **The Inferior Radio-ulnar Joint.** This occurs usually as a complication of a severe Colles's fracture, with tearing of the fibro-cartilage and ligaments, or in association with a dislocation of the radial head. It gives rise to troublesome arthritic changes, limiting and rendering supination painful.

Occasionally it occurs without fracture of the radius, the hand and radius passing forwards. The head of the ulna becomes unduly prominent, while the hand is held pronated. Flexion and extension are free, pronation and supination limited and painful. The bones must be reduced by pressure and manipulations, and fixed in plaster for three weeks. The dislocation often tends to recur.

Dislocation of the Semilunar or other Carpal Bones. This may occur by itself or complicate other injuries in the neighbourhood. The dislocation is anterior, the bone being palpable on the front of the wrist under the tendons in its abnormal situation, while there is great pain and disability; median anæsthesia is often present. In these cases a stereoscopic X-ray film is of extreme value in establishing the diagnosis (Plate IV.). Reposition is always to be attempted either by external manipulation combined with traction, or through a small dorsal incision and the use of Remijnse's ingenious hooked repositor. Extension is obtained by applying an adhesive such as masticol to the fingers of the patient, and attaching bandages to (*a*) the joined ring and little fingers, and (*b*) the middle and index fingers; these are then separated from one another and steady traction made while counter-extension is made by a towel wrapped round the patient's arm above the elbow. If this fails it is treated by exposure of the bone by an anterior incision and reposition by open operation, the wrist is fixed in plaster of Paris as for Colles's fracture, and as soon as the splint is removed physical treatment is commenced.

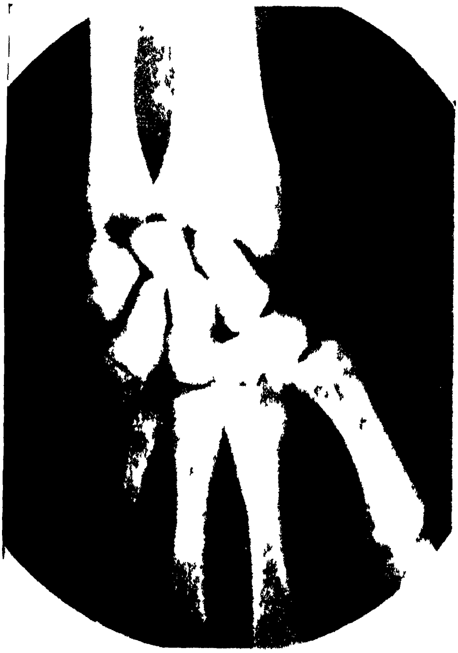
If this also fails, the condition must be treated by excision of the bone by an anterior incision, and as soon as the stitches are removed physical treatment must be begun. These cases give poor results on account of the resulting arthritis.

In association with this injury it is not uncommon to find that one or other of the carpal bones is fractured (see below). Occasionally one row of the carpus is dislocated on the other, or any one bone, especially the os magnum, displaced. These injuries are in the nature of subluxations and should be reduced by manipulation and retained in position by a carefully-moulded plaster of Paris splint for ten days. They are very rare.

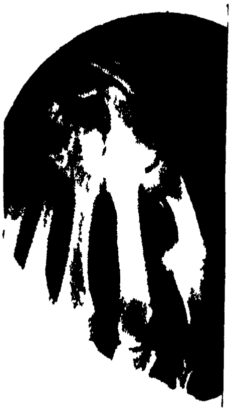
Fractures of the Carpal Bones. Any of the carpal bones may be injured, but the two most commonly affected are the scaphoid and os magnum. The fracture may be associated with dislocation of other carpal bones, particularly the semilunar, or more rarely dislocation of the whole carpus. These injuries have been recognised as comparatively common as a result of the introduction of X-rays. The fractures tend to non-union or fibrous union, as synovial fluid has free access to the fractured surfaces; they are also prone to start osteoarthritic changes. Many cases in the past were regarded as severe sprains of the wrist.

Fracture of the Scaphoid. This is produced by a fall on the outstretched hand or in boxing, the line of fracture running across the narrow part or neck of the bone. Apart from the X-ray evidence (Plate IV.), clinically there is tenderness in the anatomical snuff-box and pain on or interference with dorsiflexion of the wrist. There is marked increase in the antero-posterior width of the wrist, while the most characteristic feature is the presence of a localised, tender, boggy swelling on the back of the wrist over the scaphoid bone. Crepitus is absent, and the pain and disability persist for weeks in spite of treatment.

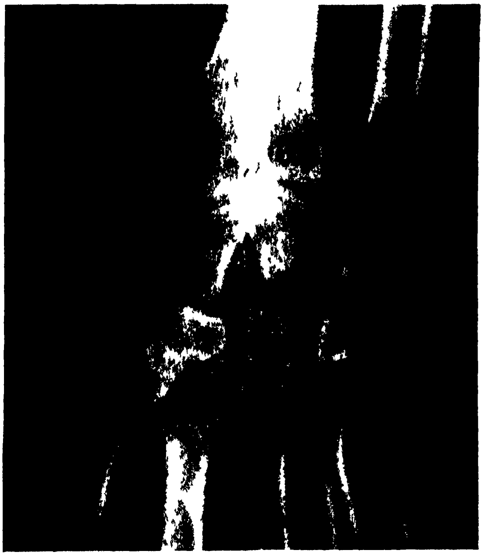
Treatment. If full dorsiflexion can be obtained, the wrist should be immobilised in a carefully-moulded plaster for at least two months, and may be as long as six months. Full use of the wrist should be regained in three months. If after this time the wrist is still painful, owing to non-union of the fragments, the bone should be drilled to promote bony union and again fixed in plaster; the lower fragment or the whole bone should *never* be excised. In a very few cases only it will be found that pain and disability will persist and render this excision necessary. An X-ray photograph always should be taken, as it is very doubtful if it is worth while drilling the bone if much arthritis is present, for the resulting wrist joint is always weaker than normal and occasionally painful.



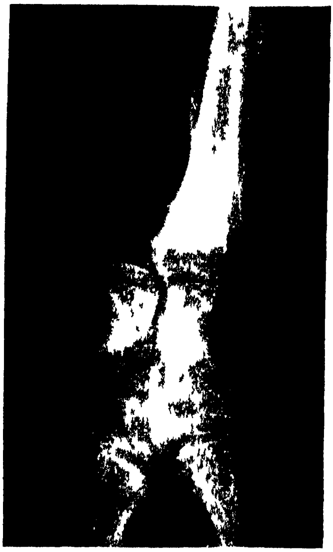
Fractured scaphoid



Bennett's fracture.



Dislocation of the semilunar bone Antero posterior view



Dislocation of the semilunar bone Lateral view.

Fracture of other Carpal Bones. The diagnosis rests entirely on X ray examination, and the treatment and prognosis are similar to fracture of the scaphoid.

Sprains of the Wrist. These are very common injuries and may be exceedingly painful and crippling; they are due to falls, twists and blows, which force the joint into extreme positions of flexion, extension or rotation. Marked swelling occurs and may resemble a Colles's fracture, while *in every case an X-ray photograph, preferably stereoscopic, must be taken* to ensure that no bone, such as the scaphoid, is cracked or displaced. In such injuries the bony points have their mutual relationship unaltered, while the swelling and tenderness are most marked over the individual ligament, which is damaged; effusion into the surrounding tendon sheaths, with silky crepitus (see p. 391), sometimes also will be present. Any movement which tends to stretch the damaged ligament is very painful, while other movements may be comparatively painless. After a few hours bruising and ecchymosis may appear. It should be remembered that severe sprains are often accompanied at the time of the injury by a cracking sound and a feeling as though something had snapped.

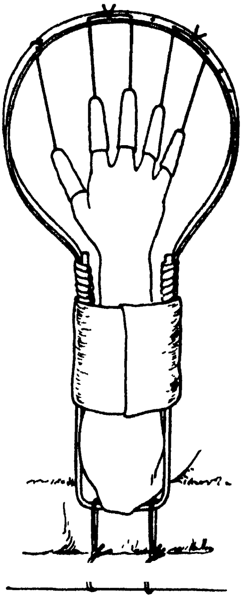


FIG. 238. Metacarpal frame.

Treatment. This consists in massage and movements commenced within twenty-four hours, while the wrist is supported in a firm bandage and sling. All movements which stretch the damaged ligament must be avoided, while when the patient begins to use the hand again it is well to strap the wrist so that this ligament cannot be stretched.

Fractures of the Metacarpal Bones. These are common and usually due to direct violence, two or more bones being broken, while as they are frequently due to crushes, they are often compound. The line of fracture may be transverse or spiral and, if displacement occurs, it is in the nature of a posterior angulation. There is, however, usually very little displacement, as the neighbouring metacarpals act as splints. The site of fracture as a rule is in the shaft, but occasionally the bases are broken, in which case the fragments are impacted. The injury is very painful, while marked swelling of the whole of the hand soon occurs. Crepitus is often felt, while traction on the finger always produces pain if a fracture is present.

Treatment. Reduction is effected by long-axis traction. After reduction, or if reduction prove unnecessary (as is usual in transverse fractures), immobilisation may be carried out by placing a roller bandage in the palm, closing the hand over this and applying a firm bandage or strapping. If the line of fracture is spiral and shortening is likely to occur, the fracture may be treated with continuous extension. This is obtained by a frame attached to the wrist, having extending tapes fixed to the fingers by strapping, or transfixion wires (Fig. 238). Fixation should be maintained for ten days, after which time massage and passive movements may be commenced. Active movements can be started in three weeks and full use of the hand allowed in five.

Union as a rule progresses rapidly and the functional results are fairly good.

Fracture of the Base of the First Metacarpal (Bennett's Fracture). This is a common fracture, which runs obliquely across the base of the thumb metacarpal bone, detaching the greater part of the articular surface. It resembles closely a dislocation of the carpo-metacarpal joint, and is usually produced by transmission of direct violence from the head of the bone while boxing. There are pain and tenderness over the base of the first metacarpal, where an obvious swelling is usually present, and on attempting to use the thumb, the movements of which are in addition much limited. The major part of the bone is displaced backwards and upwards, forming a prominent swelling at the back of the joint, the small proximal part remaining attached to the trapezium. Pain and swelling are very marked, while crepitus is never obtained. The fracture is often not recognised until an X-ray photograph is taken; if not recognised it leads to much disability (Plate IV.).

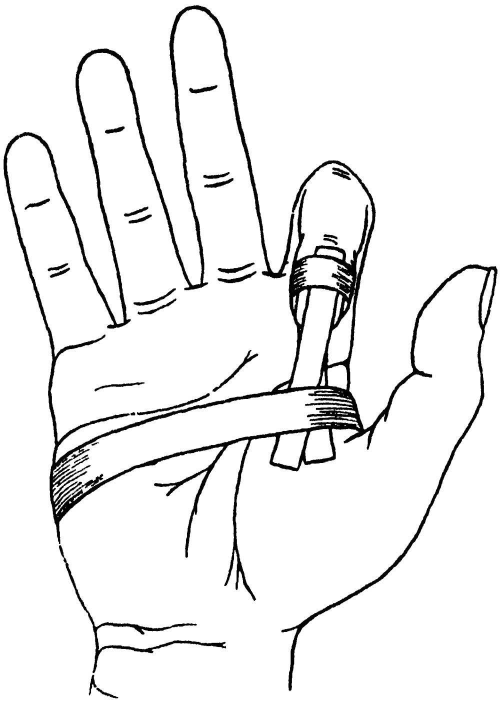


FIG. 239. Treatment of a fractured phalanx and mallet finger.

Treatment. Reduction is effected by long-axis traction, and the hand fixed in a cock-up plaster splint, with the thumb in abduction as though grasping a tumbler. Finger movements are commenced at once. The plaster is maintained for three weeks, after which the thumb is strapped and active movements commenced. No heavy work should be permitted for three months.

A somewhat analogous injury is a sprain of the metacarpo-carpal joint of the thumb, with consequent traumatic arthritis.

Fractures of the Phalanges.

(1) *The Shaft.* This breaks, as a rule, at its centre and usually as the result of direct violence. The soft tissues covering the bone are so thin that the fracture is often compound. There is little displacement, but there is distortion of the normal posterior bowing of the phalanx. Unnatural mobility and crepitus are usually present, but the swelling may cause the fracture to be missed. If shortening is present, it should be overcome by traction, if necessary by a wire, and the finger then be fixed either in flexion, by strapping it to the palm of the hand (Fig. 239), or in extension on a straight splint. Fixation should be maintained for three weeks.

(2) *The Base.* A fracture in this situation is met commonly in the distal

phalanx. It is produced by violent dorsiflexion or flexion, being a sprain-fracture of the tendons inserted into the bone. Union progresses very slowly and is associated with arthritic changes in the joint. The results are unsatisfactory whatever treatment is adopted, but immediate massage and mobilisation give the best results. No operative interference is advisable.

Dislocation of the Metacarpo-phalangeal Joint of the Thumb. This is most commonly a backward dislocation which is caused by extreme dorsiflexion of the thumb, the head of the metacarpal bone passing forwards between the two heads of the flexor brevis and forming a prominence in the palm, while the phalanx is held stiffly on the back of the metacarpal bone by the adductor muscles. The hyperextended attitude of the thumb is therefore very characteristic. This dislocation is notoriously difficult to reduce; one reason may be that the two heads of flexor brevis grip the phalanx, but it is more probable that the proximal phalanx slips back over the head of the metacarpal, carrying with it the glenoid ligament, which interferes with reduction. A further cause of difficulty in reduction is the fact that the flexor pollicis longus tendon winds round the metacarpal neck.

Forward dislocation of the joint is rare; it results from forced flexion and gives rise to a characteristic deformity, the head of the metacarpal projecting backwards, while the phalanx with its base forms a prominence on the thenar eminence. Lateral dislocation of the thumb is very rare.

Treatment. Reduction is attempted by hyper-extension, exaggerating the deformity, long-axis traction and finally flexion, pushing back the head of the metacarpal and forcing the phalanx forwards. This seldom fails to reduce the deformity, which, however, often recurs as soon as the extension ceases, as the stiff glenoid ligament has slipped back between the joint surfaces. If this occurs a tenotome is inserted in the middle line posteriorly to divide the glenoid ligament longitudinally and reduction by manipulation attempted again. Should this fail open reduction should be carried out through a postero-lateral incision. After reduction the thumb should be strapped for ten days, but it may be used after the first forty-eight hours. Reduction of the forward dislocation is easy, but it is very liable to recur if not firmly fixed.

Dislocation of the Interphalangeal Joints. These injuries sometimes occur, the distal phalanx slipping on to the back, front or side of the proximal one, and in many cases are accompanied by a "chip-fracture" of the proximal phalangeal head. Reduction is effected by traction and a finger-splint applied for three days. After this massage is commenced, but persistent arthritis is likely to follow. These dislocations are frequently compound and may then require amputation of the fingers.

Metacarpo-phalangeal Dislocations of the Fingers. These are sometimes seen, and the phalanx generally passes backwards. The deformity is similar to that which sets in when this dislocation occurs in the thumb, and the same difficulties in reduction will occur in the backward variety. The treatment is similar.

Bruises of the Fingers. Injuries of the fingers are sometimes seen in which, though no fracture or dislocation has occurred, the accident is followed for weeks and months by a painful, swollen and slightly deformed finger. The X-ray photograph in such a case shows no bony changes and the condition is due to a severe bruising of the bone and periosteum followed by a subperiosteal hæmatoma. The condition will get right after several months and its recovery is hastened by massage.

Mallet Finger (Dropped Finger). This is a persistent flexion of the terminal phalanx of the thumb or a finger, which the patient cannot correct and which follows a severe blow upon the terminal phalanx of the digit when in an extended position. It is due to rupture or stretching of the extensor tendon just above its insertion into the terminal phalanx.

Treatment. If the condition is seen early it is treated by ensuring hyperextension of the terminal phalanx for three weeks, and this should be done by strapping the finger down into the palm of the hand so that the terminal phalanx is hyperextended; the extensor tendon is thus prevented from pulling taut by means of its attachment to the flexed second phalanx (see Fig. 239). In an old-standing case, or if the deformity persists after the above treatment, open operation must be performed and the extensor tendon sutured or shortened, or an arthrectomy performed to secure ankylosis in a useful position. The finger must be fixed again in full extension for ten days and then massage and movements commenced.

This is a difficult little operation to perform, as there is no satisfactory tissue to which the tendon can be sewn firmly. It may be wise actually to drill the terminal phalanx and sew the tendon to this. The results are not very good.

CHAPTER XVII

INJURIES OF THE PELVIS AND LOWER LIMB

Surgical Anatomy. Injuries of the lower limb may be considered under the headings of those in the neighbourhood of the pelvis and hip, those of the thigh and knee, and those in the neighbourhood of the ankle and foot. Around the pelvis are certain important subcutaneous bony points; the crest of the ilium, with its tuberosity and prominent anterior superior iliac spine, is easily felt under the skin, and the two posterior iliac spines are indicated by dimples, while the whole of the posterior surface of the sacrum can be palpated. The pubic symphysis, spine of the pubes and greater part of the descending ramus of the pubis also can be felt, this spine being easily detected by running the finger up the tendon of adductor longus, and the ischial tuberosity can be detected on pressing deeply upwards into the buttock from the natal cleft. Below and behind the anterior superior spine the great trochanter is easily palpable, but the rest of the femur until we reach its lower end is deeply buried in muscles.

The *hip joint* is an exceedingly strong joint, the strength of which depends partly upon its bony formation, partly upon the strong ligaments which retain it, and partly upon the muscles which surround it, its articular capsule in particular being particularly strong. This surrounds the acetabulum and passes on to the neck of the femur, so that the whole head of the bone is intra-articular and the antero-inferior aspect of the neck is also within the joint; a portion of the posterior and outer aspect is, however, extra-articular. The weakest part of this capsule is, without doubt, the lower and back part. No part of the hip joint can be palpated from the surface, as it is deeply buried in muscles. In adults it lies roughly on the same level as the tip of the great trochanter, though in children it may be a trifle higher, while a vertical line drawn upwards through the centre of the hip joint will pass through the mid-Poupart point.

There is no doubt that the neck of the femur is much the weakest part of the upper end of the bone, and any strain or stress put upon the femur itself falls very largely upon this neck; this part of the bone is therefore frequently fractured. This neck is covered with a thick vascular periosteum, while the capsule of the joint appears to reflect certain strong bands of tissue along the neck of the bone which are known as the cervical ligaments of Stanley, and it is probable that these, in conjunction with the periosteum, are responsible for the nourishment of the head of the bone.

There are certain important clinical lines and tests which are used in the neighbourhood of the hip joint.

(*a*) **Nelaton's Line.** This is a line drawn from the anterior superior iliac spine to the most prominent part of the ischial tuberosity. This line just touches the tip of the great trochanter in the normal limb. It is of special use, as it provides a positive measure of the position of the femur and hip joint without comparing it with that on the opposite side. For the line to hold true the limb must be in its normal position and not abducted.

(*b*) **Bryant's Triangle.** To form this triangle one line is drawn from the anterior superior iliac spine to the tip of the great trochanter, this line being called Line A. From the anterior superior spine a second line, Line B, is dropped perpendicular to the bed, while a third line, Line C, is drawn from the tip of the great trochanter perpendicular to Line B. This completes the triangle. It is done on both sides of the body and the length of the two Lines C compared on the two sides. Thus shortening of Line C denotes upward displacement and lengthening denotes downward displacement of the great trochanter. This test necessitates comparison of the two sides of the body; its great advantage, however, is that it can be performed with the patient lying flat on his back and without turning him over.

(c) A third test of this nature is known as **Chiene's test.** This is performed by laying one measuring tape across to join the two anterior superior spines and another to join the tips of the two great trochanters. It will then be seen at once whether these two lines are parallel or not.

These tests are only of use in demonstrating shortening of the limb which is due to lesions of the neck of the femur or to displacements of its head.

It will be seen, therefore, that these three tests are devised mainly for estimating alteration of the position of the great trochanter, but it will be found that by placing the thumbs of both hands simultaneously upon the two anterior superior spines, and the middle fingers upon the tips of the great trochanters, a very good estimate of the position of the latter points will be obtained.

The length of the limb is best measured from the anterior superior iliac spine to the internal malleolus, keeping the knee straight and the two limbs parallel. In addition to real shortening or lengthening of the limb, in many cases apparent lengthening or shortening will be present, owing to tilting of the pelvis (see p. 623). Apparent alteration in the length of the limb is measured from the umbilicus to the internal malleolus by comparing the two sides.

Wasting in diseases and injuries of the hip joint occurs first and is most marked in the muscles of the buttock. This is sometimes shown by disappearance of the fold of the buttock, while it always can be demonstrated by laying the patient upon his face and asking him to raise his head and shoulders from the couch without the use of his hands.

In the neighbourhood of the *knee joint* certain important bony points will be found. Thus the two condyles and epicondyles of the femur will be felt, the internal one being the more prominent. Below these the line of the knee joint can be distinguished, especially when the limb is flexed, while on the outer side below the external condyle the rounded and cord-like external lateral ligament will be felt. Above the internal condyle, on pressing deeply between the muscles, the adductor tubercle will be distinguished, with the tendon of the adductor magnus running up from it. This marks the epiphyseal line of the femur and the upper limit of the trochlear surface. Below and slightly in front of the internal condyle the internal tuberosity of the tibia can be felt, while at the outer side at a slightly lower level still, and about 1½ inches farther back, the head of the fibula will be discovered, and into this the tendon of the biceps can be felt to run. In front the tubercle of the tibia will be felt on the same level as the head of the fibula, with the patellar tendon running into it, while the patella itself will be felt above this, the whole of its anterior surface being subcutaneous.

Just below the head of the fibula the external popliteal nerve winds round the neck of the bone, and sometimes it can be felt here rolling under the fingers. A blow in this situation gives rise to pain and tingling in the distribution of the nerve, while care must be taken in putting on plaster of Paris not to make it too tight at this spot.

The knee joint is one of the most frequently injured joints in the body. It derives its strength almost entirely from the strong ligaments which hold it in position, especially the crucial ligaments, little aid being given either by the shape of the bony surfaces or by muscles around the joint. The synovial cavity of this joint is large, extending from the head of the tibia for an inch or two up the femur. This cavity is prolonged into a large cul-de-sac which runs up under the quadriceps muscle on the front of the femur for a distance of about three fingers' breadth above the upper border of the patella. The superior tibiofibular joint has a separate synovial cavity of its own.

In diseases and injuries of the knee joint wasting appears first and is most noticeable in the quadriceps extensor, and especially in the vastus internus portion of this muscle, and this wasting of the quadriceps may become very marked. When the knee is completely extended it is more or less locked in this position and no strain is put upon the muscle, but when it commences to flex great strain is put upon the quadriceps, which, for the time being, may carry the whole weight of the body. Thus wasting and weakness of the quadriceps by itself may give rise to a great deal of disability and weakness of the whole limb, and in the treatment of any abnormal condition of the knee joint restoration of power and tone in the quadriceps will be of the greatest importance.

Around the knee joint are a large number of bursæ; few of them, however, are of surgical importance. It must be remembered that the large prepatellar bursa lies partly over the lower half of the patella and partly over the ligamentum patellæ. Behind the ligamentum patellæ lies a smaller bursa and an important pad of fat, which may not infrequently be the cause of symptoms. Of the other bursæ round the knee joint the semimembranosus one, which may communicate with the knee joint, and those in the neighbourhood of the sartorius and gracilis tendons are the only ones likely to give rise to surgical lesions (see Chapter XIII., p. 399).

On passing down the leg it will be found that the whole of the anterior border and internal surface of the tibia are subcutaneous, the entire internal malleolus being palpable. The fibula only becomes subcutaneous in its lower half, but the outer surface of the lower half of this bone is subcutaneous and readily palpable. The external malleolus lies rather farther back and half an inch below the internal one. Below the external malleolus the external tuberosity of the os calcis can be felt, while in front of this the peroneal tubercle and farther forward still the base of the fifth metatarsal are palpable. On the inner side, below the internal malleolus, the internal tuberosity of the os calcis can be felt; about one inch below the tip of the malleolus the sustentaculum tali is palpable, while the tuberosity of the scaphoid is obvious about one inch in front of and slightly below the tip of the malleolus. The internal cuneiform and the whole of the first metatarsal also can be felt easily. The length of the leg is best measured, for comparison with the other side, by noting the distance from the upper border of the patella to the tip of the internal malleolus.

The *ankle joint* is a very strong joint deriving its strength chiefly from the configuration of the bones which form it, while it is strengthened by strong ligaments. Its synovial membrane is extensive and continuous with that entering into the lower tibiofibular joint. It is not, however, connected with the synovial membranes which form the complicated intertarsal joints. The line of the joint runs about half an inch above the tip of the internal malleolus. The epiphyseal line of the fibula is roughly at the level of the upper part of the ankle joint, while that of the tibia is about half an inch higher.

Considerable confusion sometimes exists with regard to the movements of the foot and ankle. Moving the toes up towards the front of the leg is usually described as dorsiflexion, though morphologically it is strictly extension of the joint, while pointing the toes down is called plantar flexion. Inversion and eversion consist in inclining the foot so that its sole looks towards or away from the middle line of the body, while adduction and abduction mean that the whole foot is rotated so that the big toe is turned towards or away from the middle line of the body respectively.

It cannot be insisted upon too strongly that in all injuries X-ray photographs must be taken, and in the case of fractures and dislocations subsequent pictures should be taken to ensure that reduction is complete and the corrected position maintained under treatment. General anæsthesia must be employed in all cases to secure the muscular relaxation necessary to ensure reduction.

FRACTURES OF THE PELVIS

These are produced by severe direct violence such as crushes, gunshot wounds, and most commonly street accidents. Their seriousness lies in the risk of associated visceral injuries. They may be considered under the headings of injuries of the pelvic girdle as a whole and injuries of isolated portions of it.

Fractures of the whole Pelvic Girdle. In some cases a separation of the pubic symphysis occurs, but the site of the fracture usually lies in the horizontal and descending rami of the pubis and rami of the ischium on one side or both sides, associated frequently with a fracture posteriorly near the sacroiliac synchondrosis on the opposite side or on both sides. The bone breaks on the outer side of the synchondrosis, as fracture occurs more readily than rupture of the strong ligaments of the sacroiliac joint. Displacement is, as a rule, slight, but the violence of the injury may push back the symphysis pubis, if this is separated completely. These injuries in particular are usually the result of severe crushes, heavy falls and blows.

As well as the fracture involving the true pelvis, there may be associated fractures of the alæ of the ilia.

The associated visceral injuries may be due to perforation by sharp bony fragments, to the forcing apart of the bones, or they may be the result of the violence independent of the fracture.

The bladder and urethra are affected most commonly and more rarely the iliac blood vessels, the sacral nerves, the rectum or vagina. The urethra is torn where it passes through the two layers of the triangular ligament and the viscera may be injured either within or outside the peritoneal cavity.

Diagnosis. In addition to a history of violent crushing, there is usually bruising over the groins, in the perineum, or over the ilia. Collapse is well marked and the patient is unable to stand, while coughing is painful and the patient experiences a sense of falling to pieces. There is marked tenderness at the site of the fracture and pain on moving the legs, which usually lie in a position of eversion; severe pain is elicited on pressing together the iliac crests or palpating the pubic bones in the perineum or groins, while sometimes crepitus is obtainable. Rectal and vaginal examinations may assist in confirming the diagnosis, as by this means displacement of the pubic symphysis can easily be felt. If the condition of the patient will permit, an X-ray photograph should be taken to show the exact extent of the bony injury.

Treatment. Extreme care must be taken to avoid aggravating the condition by injudicious movement of the patient, who should be placed on a firm divided mattress with fracture boards beneath it; the condition of the bladder and urethra should be investigated, and the patient warned not to attempt to pass water till this has been done, a soft rubber catheter being used for this purpose. If complications are present (see below), the treatment of them in most cases will be more urgent than the actual treatment of the fracture.

Occasionally reduction of deformity will prove necessary, and in cases of severe displacement it may be effected by rectal or vaginal manipulation under anæsthesia. Immobilisation is carried out by strapping the pelvis with a many-tailed bandage extending from the umbilicus to the lower third of the thigh or using a roller towel in the same manner. Some authorities advise plaster of Paris breeches, but there is serious risk of increasing the damage by the manipulation necessary for applying these. Very careful nursing will be necessary, otherwise pressure sores may develop. It is a sound principle to tie the legs together, and they may be steadied by applying strapping extension with a small weight running over a pulley at the bottom of the bed. Fixation should be maintained for two months, at the end of which time the patient may be left free in the bed and passive and active movements at the hips with massage commenced. If X-ray examination shows that union is progressing favourably an attempt may be made to get the patient up in ten weeks, using first a walking machine and later crutches. Compound fractures of the pelvis are likely to be complicated by extravasation of urine. Severe sepsis is therefore likely to occur, and may prove fatal.

Complications of Fractured Pelvis.

1. *Ruptured Urethra* (see also Vol. II., Chapter XXI.). This is denoted by bleeding from the meatus, swelling and bruising in the perineum, often of butterfly shape, and inability on the part of the surgeon to pass a catheter. If the patient has made efforts to micturate extravasation of urine will be superadded. An attempt should be made under anæsthesia to pass and tie in a catheter. If this fails a median perineal incision should be made, the roof of the urethra be established if possible, and a catheter tied in, leaving the

floor of the urethra to heal by granulation (see Vol. II., Chapter XXI.); or an effort may be made to suture the whole urethra.

2. *Extraperitoneal Rupture of the Bladder.* This is shown by inability to pass water, but normal passage of the catheter, with evacuation of a little bloodstained urine. Shock is as a rule slight and the patient remains comparatively fit until extravasation of urine is well developed. A suprapubic exploration of the bladder, with repair of the rent and temporary suprapubic drainage, should be carried out (see Vol. II., Chapter XX.).

3. *Intraperitoneal Injury of the Bladder.* This is shown by similar signs, associated with severe shock, and later, in place of extravasation, general peritonitis. An exploratory laparotomy, with suture of the bladder, should be carried out and a catheter tied in for ten days. Intermittent catheterisation may be required for a day or two after this to prevent overdistension of the bladder (see Vol. II., Chapter XIII.).

4. *Injury of the Rectum.* This may be diagnosed by the finger or rectal speculum. If the damage is severe a temporary colostomy should be carried out, otherwise the case should be treated expectantly. Should the pararectal tissues become infected, producing pelvic cellulitis with abscesses, multiple incisions will have to be made (see Vol. II., Chapter XIX.).

Results. In the absence of visceral complications the results are good. Pelvic fractures usually unite well, and full function is regained provided convalescence is not hurried unduly. In the elderly there are the associated risks of prolonged confinement to bed and later of stiffness in the joints.

Fractures of Individual Bones.

(A) **The Ilium.** In this bone the expanded portion of the crest is often fractured by direct violence and we meet with fissured fractures, usually without much displacement, as the fragments are held in position by the surrounding muscles. There is pain in the upper part of the buttock and in the flank muscles, while a hæmatoma is usually present. Cracks frequently run into the iliac fossa, while on relaxing the muscles attached to the bone, abnormal mobility and crepitus may be detected. If they are, serious trouble may supervene if the wound becomes infected, as abscesses may form on the deep aspect of the bone.

The *treatment* consists in rest in bed for four weeks, with strapping over the affected part. The patient must be kept in such a position that the muscles attached to the fragment are relaxed. After this time function may be commenced slowly. If gross displacement has occurred, the question of operative interference, with reposition or removal of loose fragments, will have to be considered.

Occasionally, in young patients, the anterior superior spine is avulsed, being torn off by the sartorius, an instance of traction-fracture, and, if displaced, it will require fixing in position by open operation. In any case the patient should be nursed with the thigh flexed. Occasionally the anterior inferior spine has been pulled off by the rectus femoris.

(B) **The Pubis.** If this bone is fractured alone there is rarely any displacement and union occurs rapidly. Its treatment is the same as that of fracture of the pelvic girdle.

(C) **The Ischium.** Occasionally the whole bone or the tuber ischii is fractured by a heavy fall on the buttocks, while in young adults avulsion of the epiphysis of the tuber may occur as the result of great muscular violence. There is pain, swelling and stiffness in the buttock and thigh on the affected side, and these are much aggravated by any attempt to use the hamstring muscles. Treatment consists in rest in bed for six weeks, with massage and movements towards the end of this period. There is usually no displacement.

(D) **The Sacrum.** This is fractured by severe local direct violence, such as a kick or gunshot wound, and is usually comminuted. When transverse the lower fragment projects into the pelvis and may damage the rectum or sacral nerves. The lower fragment can be felt or manipulated from the rectum. There is pain and bruising in the natal cleft and cheeks of the buttocks. The treatment is the same as that of fracture of the whole pelvis.

(E) **The Coccyx.** This is usually fractured by a direct blow during a fall on the buttocks, but the injury sometimes occurs during parturition; it is associated with pain out of all proportion to the injury; this pain is felt on sitting, walking or defæcation. The displacement may be palpable on rectal examination and will be visible on an X-ray film. The case is treated by rest in bed after correcting any deformity, but if union in bad position should occur, it is best to excise the whole bone. In cases where the lower fragment remains displaced (and in some where no displacement is palpable), months or years afterwards severe pain may set in (**coccydynia**), and require excision of the bone (see Vol. II., Chapter III.).

Fractures of the Acetabulum.

(1) **Fracture of the Posterior Lip.** This is produced at the same time as, and is a complication of, posterior dislocation of the hip joint. Its presence is suspected if the dislocation recurs after reduction or if crepitus can be felt. The treatment consists in immobilising the thigh in external rotation and abduction, in plaster of Paris breeches for six weeks.

(2) **Fracture of the Acetabulum Proper.** This is produced by direct violence, transmitted through the head and neck of the femur. In most cases a stellate fracture of the acetabulum is produced, but in an extreme case there may be fracture—or in young patients separation—of the cartilaginous junction of its component parts, with central dislocation of the head of the femur, the head of the bone being driven through into the pelvis. In simple fracture the patient should be immobilised in plaster for three weeks, and massage and movements commenced and weight bearing allowed in six weeks. There are risks of osteoarthritis developing later.

In *central dislocation of the femur* there is simulation of a fracture of the neck of the femur, but there is marked loss of mobility and a marked depression of and inward displacement of the trochanter. Shortening is marked, while there may be severe pain down the course of the obturator nerve; the head of the bone may be palpable per rectum. An attempt should be made to reduce the condition by long axis traction and manipulation or by prolonged traction by means of a Steinman's pin inserted above the femoral condyles, the limb being kept in abduction, after which the hip joint should be immobilised in plaster for six weeks. The thigh must be in the position of 5 degrees abduction, 20 degrees flexion, and 10 degrees external rotation. In these cases severe traumatic osteoarthritis is only too likely to supervene.

STRAINS AND DISLOCATIONS OF THE SACROILIAC JOINT

These injuries may occur from direct or indirect violence. Their occurrence has been given great prominence by some American authorities. The condition of complete dislocation has never been recorded and, at most, it is a slight subluxation that occurs; there is evidence that certain types of chronic pain in the hip and abdominal regions are due to this cause. Pain and tenderness in the iliac fossa are marked, so that, on the right side, appendicitis may be suspected. Sciatic pains down the thigh are also met with. In the acute stage rest is indicated with, later, manipulation, massage and electrical treatment. If the condition appears intractable, a modified back brace should be fitted, while in severe cases fixation may be obtained by a fibular peg driven through the ilium into the sacrum. We have seen one case where an orthopædic surgeon drove such a peg right through the cauda equina.

Spondylolisthesis. This condition is described in Vol. II., Chapter III.

DISLOCATIONS OF THE H P JOINT

The hip joint is so strong that these are distinctly rare conditions which are met with in adult life, and almost entirely in men. In the elderly similar violence produces a fracture of the neck of the femur rather than a dislocation, while in the young a fracture or separated epiphysis will result. The dislocation may be either posterior or anterior, of which the former is much the more common. It is produced by severe violence applied while the muscles guarding the joint are taken unawares, the head of the femur usually leaving the socket at its lower and back part, the ligamentum teres being torn. In what are known as the typical dislocations, the "Y"-shaped ligament of Bigelow remains intact and acts as a fulcrum upon which the femoral head is levered out of its socket. Rupture of the "Y"-shaped ligament is very rare, and it is only when this has occurred that the uncommon atypical dislocations can arise.

Dorsal Dislocations.

(*a*) *Gluteal.* (*b*) *Sciatic.*

These are the commonest dislocations and are due to heavy falls on the leg or may be produced when a man, squatting with the thighs adducted, is struck by a heavy weight on the lower part of the back; they are not uncommon in motor accidents. The femoral head leaves the posterior and inferior part of the acetabulum, often producing a chip-fracture of this structure in so doing. The shaft of the femur acts as the long limb of a lever, the "Y"-shaped ligament as the fulcrum, and the head of the bone as the short arm of the lever. The head passes on to the dorsum ilii, either above or below the tendon of the obturator internus, usually the former. If it passes above the tendon it is known as the **Gluteal**, if it passes below as the **Sciatic** type of dorsal dislocation.

Clinical Features and Diagnosis. On examining the patient the leg is found adducted, flexed and internally rotated, with the ball of the great toe resting upon the dorsum of the opposite foot, and the knee crossing the lower third of the opposite thigh. There is apparent and real shortening of about 1½ inches, with emptiness in Scarpa's triangle; the great trochanter is raised and the femoral head is palpable in the buttock in its abnormal situation. All movements are restricted and painful and are associated with elastic rebound. Pain and shock are considerable.

The normal depression behind the great trochanter disappears, the gluteal fold is raised, and there will be considerable lordosis. Occasionally the "Y"-shaped ligament of Bigelow is ruptured and then the rare form of **dorsal dislocation with eversion** occurs. This closely resembles a fracture of the neck of the bone. In the sciatic type of dislocation the amount of true shortening is not so great as in the gluteal type, while all the other clinical features are similar to the above condition but less marked.

These backward dislocations are usually easy to recognise except in stout people.

Anterior Dislocations.

(*a*) *Obturator.* (*b*) *Pubic.*

These are produced in a subject squatting, with the thighs abducted widely, by blows or weights falling on the lower part of the back, or by wide abduction of the legs. They may be produced when a person embarking in a boat remains undecided whether to get in or to remain on land. The head may remain on the obturator internus—the **obturator** type; or pass up on to the ilio-pectineal eminence—the **pubic** type.

Clinical Features and Diagnosis. It is not uncommon for patients with this condition to be able to walk. In this case the leg is found flexed, abducted and externally rotated, with apparent lengthening; in a few cases real lengthening occurs. The head is palpable in its abnormal situation and there is serious pressure upon the femoral vessels and nerve. In the pubic form all the clinical features are more marked, while the anterior crural nerve is liable to be pressed upon (Plate V.).

Differential Diagnosis of Dislocations of the Hip. Pathological dislocation may be excluded by a consideration of the history. Fracture of the upper end of the femur should not present difficulty. Occasionally, particularly in hysterical subjects, the condition can be imitated closely, but all measurements will be found to be normal and an X-ray examination reveals the actual state of affairs.

Treatment. Reduction should be carried out as soon as possible under full anæsthesia. The patient should be placed on a firm mattress on the floor or on a low couch, and the pelvis held steady by an assistant. In the case of a dorsal dislocation, using the leg as a lever, with the knee flexed, the thigh is further flexed, adducted and internally rotated, that is to say, the deformity is exaggerated. This is done because the "Y"-shaped ligament is the chief obstacle to reduction, and the movement of flexing the hip, in particular, relaxes this structure. The thigh is then abducted, externally rotated and lifted upwards from the floor. It is finally extended, when reduction should occur.

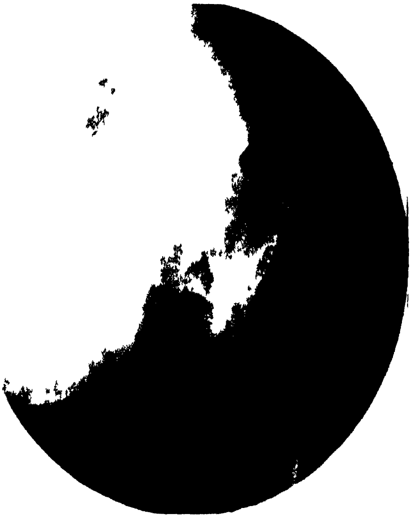
In the case of an anterior dislocation the deformity is first exaggerated and the thigh then adducted, internally rotated, lifted up and extended. These methods are known as Bigelow's circumduction methods for reduction. Should they fail reduction must be attempted by strong traction with a block and tackle.

After reduction the leg is immobilised between sandbags and massage commenced. Active movements at the hip may be commenced with the patient in bed in three days and should be free in ten. No weight should be borne for three weeks. If the acetabulum is fractured the limb should be immobilised for six weeks (see p. 488).

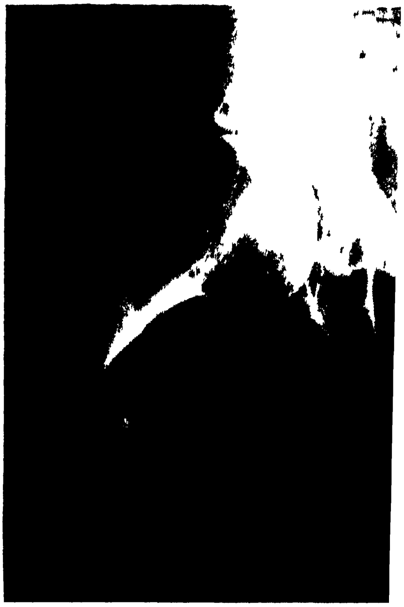
In most cases the results are satisfactory and good function should be restored, but in the elderly extensive arthritic changes are likely to occur in the joint.

Unreduced Dislocations. Though it is quite impossible to lay down any law with regard to the time limit after which dislocations may be reduced, an attempt at reduction by manipulation may succeed up to two months from the time of injury; severe violence must not be used, however, as it may lead to fracture of the femoral neck or damage to nerves and vessels. If manipulation fails, an attempt may be made to reduce the dislocation by means of open operation; if this fails it will be best to excise the head of the bone or to perform an arthrodesis.

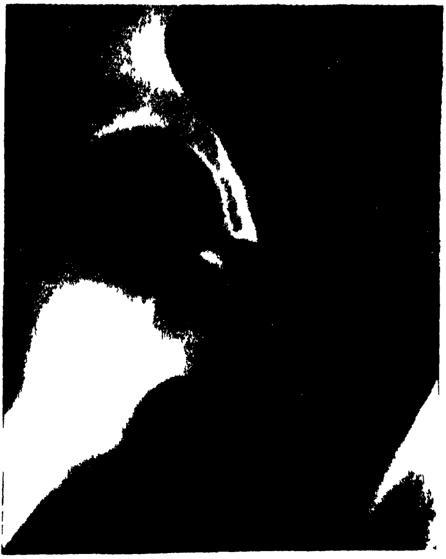
PLATE V.



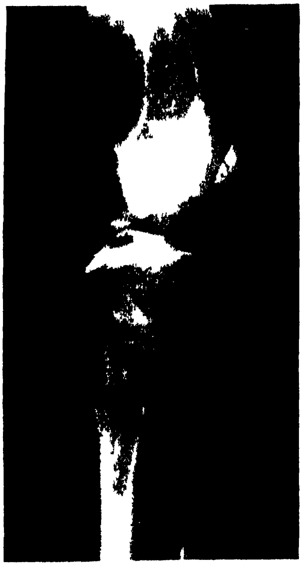
"Intracapsular fracture" of the neck of the femur.



"Extracapsular fracture" of the neck of the femur.



Anterior (obturator) dislocation of the hip.



Fracture of the patella with separation.

Sprains of the Hip Joint. These are rare, but *contusions* are not uncommon from blows over the great trochanter or from force transmitted through the leg. Pain on moving the joint, with muscular spasm, is present, and the joint tends to assume the position of ease, that is to say, flexion, abduction and external rotation. There is no shortening and the relative position of the bony points is unaltered. The diagnosis may be difficult on account of the pain and swelling, and in most cases an X-ray picture will be negative.

The *treatment* consists in rest in bed combined with massage. Recovery should be rapid, but in elderly people there is a grave liability for severe arthritic changes in the joint to follow; absorption of the neck of the femur sometimes occurs and coxa vara may develop in children.

Congenital Dislocation of the Hip. (See Chapter XXI., p. 675.)

FRACTURES OF THE FEMUR

In these fractures a correct anatomical result is absolutely essential for good function. In the past, owing to lack of appreciation of the factors governing correct treatment, it was accepted as inevitable that there should be shortening, with consequent poor function. Later, recognising this fact, it became the fashion to operate on every case if possible, as the only certain method of securing a tolerable result. As a result of the extensive experience of the last war we know now that, with correct splintage, it should be possible to obtain union in good position with not more than half an inch of shortening. It must be pointed out, however, that most of the war cases were cases of compound fracture due to gunshot wounds, as a result of which muscular spasm was abolished in a way which made treatment by extension easy.

At either end of the femur a very important joint is situated, and unless the femur is in correct alignment abnormal strain will be thrown upon these, with the result that osteoarthritis will develop.

Fractures of the femur may be considered conveniently under three headings:—

1. Fractures of the upper end.
2. Fractures of the shaft.
3. Fractures of the lower end.

Fractures of the Upper End. Here again we can recognise four distinct types:—

1. (*a*) Fracture of the broad part of the neck, or "extracapsular" fracture.

(*b*) Fracture of the narrow part of the neck, or "intracapsular" fracture. These two forms of fracture are very different in the type of person whom they affect, the nature of the causative violence, and in their results (see pp. 492–496).

2. Fracture-separation of the upper epiphysis.

3. Fracture or separation of the great trochanter and other prominences.

The first two of these varieties are both fractures of the neck.

(1) FRACTURES OF THE NECK OF THE FEMUR

(*a*) **Extracapsular,** *i.e., through the broad part or base of the neck.* This is always intracapsular at some point, so that the old name is incorrect; the intracapsular portion of the fracture is usually in front. It occurs as a rule in strong adult males as a result of heavy falls and blows over the great trochanter, or less commonly from violence applied along the long axis of the femur. It tends to be impacted and comminuted, while the head and neck are sometimes driven as a wedge into the top of the shaft, chipping off the greater and lesser trochanters; in many cases the fracture consists of a marked comminution of the whole upper end of the bone.

As a result of the impaction, function may be maintained, a point to be borne in mind, as the patient may be able to walk into hospital. As a rule, however, shock is severe, there is local bruising and ecchymosis, and loss of function is well marked.

Under the heading of fractures of the broad part of the neck we include the so-called **Pertrochanteric Fracture of Kocher.**

Clinical Features and Diagnosis. The position of the limb is characteristic. The thigh is drawn up and externally rotated. In some cases of impaction the external rotation is absent, but it is usually marked. Bruising and tenderness are present over the great trochanter, which is broadened, anteroposteriorly. Crepitus is often absent owing to impaction, and no attempt should be made to elicit it. There is real shortening as measured from the anterior superior spine to the internal malleolus, often more than one inch, while the great trochanter is raised above Nelaton's line, and as the result of the real shortening the iliotibial band is lax. Loss of power in the leg is well marked and the limb lies helpless unless impaction is present, while finally X-ray films reveal the condition. In many cases a swelling can be felt in the outer part of Scarpa's triangle (Plate V.).

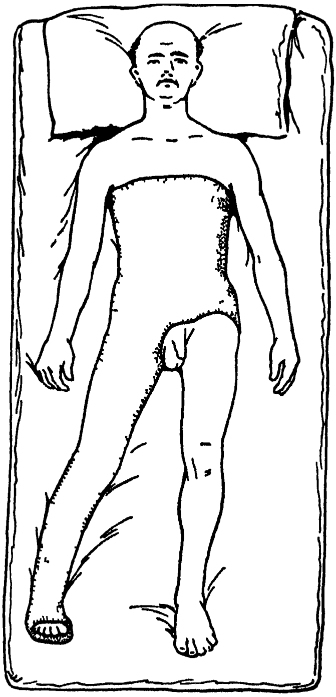


FIG. 240. Plaster of Paris splint for fracture of the neck of the femur.

A few cases are seen in which inversion of the limb is present. All the signs, especially the shortening and eversion, are much less marked when impaction occurs.

The differential diagnosis has to be made from severe contusions, dislocations and osteoarthritis of the hip joint.

Treatment. Reduction should be effected under full anæsthesia by long-axis traction after initial circumduction to break down impaction. Long-axis traction can be exercised conveniently by means of Hawley's or Putti's table (see Fig. 213); or the deformity having been corrected by inversion and extension of the hip while steady traction is maintained, and the position checked by measurement and X-ray examination if possible, a Steinman's pin or Kirschner's wire should be inserted through the lower fragment just above the condyles. The limb having been slung in a Thomas's splint in slight abduction, a suitable weight should be attached to the traction pin. For an adult male 20 lbs. is usually necessary for the first forty-eight hours, but this can be reduced considerably after that period. In our experience it is better in fractures of the femur to use a Steinman's pin than a Kirschner's wire, as the latter is inclined to bend or even break under the weight necessary to pull out a fracture. A perineal strap attached to the head of the bed may be used. To promote counter-extension the foot of the bed should be raised

12 inches. The after-treatment is similar to that given above, and bony union is the rule, though this is sometimes slow in taking place, and must be checked by X-ray examinations at frequent intervals. In cases where the pin or wire has been employed, when the deformity has been corrected and the position checked by measurement, the limb can also be immobilised in abduction in plaster of Paris, while the extending forces are still at work.

The alternative method of treatment, when the patient is not in hospital or where the absence of surgical asepsis renders the introduction of a pin inadvisable, is that, following correction of the deformity, the limb should be immobilised in abduction in plaster of Paris while the extension is still applied.

As the fracture usually is seen in robust patients there is no objection to prolonged rest in bed.

To immobilise the hip joint in plaster it is necessary to fix the pelvis and thigh. This is achieved most successfully by applying a plaster, taking in the pelvis, and reaching up to the umbilicus. At the same time the whole of the leg on the affected side and the thigh on the sound side must be included. If it is required to have an ambulatory plaster, the hip remaining fixed, this can be carried out only by leaving the whole of the leg on the sound side free. In this case, to check movement of the pelvis it will be necessary to carry the plaster high up on the chest wall on the sound side. Even then there is a tendency for the pelvis to shift, and the method is not as safe as one which includes both thighs. In applying plaster of Paris spica splints for injuries of the hip and femur, traction is exerted through the feet, which should be encased in felt or plaster boots (see p. 417).

All parts to be covered in plaster are padded with wool, taking particular care in the region of the buttock and over the lower abdomen, where alterations in girth from feeding, respiration, or distension of the bladder are to be expected. This alteration in girth is most marked in the case of children. The plaster should fit round the bony points of the pelvis, above the condyles of the femur, and above the two malleoli. Such a plaster will not stand stresses and strains unless strengthened, the places requiring particular attention being Scarpa's triangles, a point just below the knee, and in the region of the gluteal folds. These points may be strengthened by incorporating wooden laths or steel slats, or better still, sandwiches made of plaster bandage. A transverse steel bar always should be incorporated, joining the two knee joints, and may be wrapped round with plaster bandage.

In the case of the fracture under consideration, the pelvis and affected leg down to the balls of the toes, and the sound leg down to the lower third of the thigh, should be fixed in plaster. The limb must be in the position of slight flexion, full abduction and mid-rotation, that is to say, with the toes pointing vertically upwards.

This plaster should be maintained for at least two months. At the end of this time the plaster is removed, if X-ray examination shows that union is progressing favourably, and massage and passive movements are commenced in bed. During this time a walking caliper splint is fitted and the patient allowed up in this in three months. It should be worn for a further three months, otherwise traumatic coxa vara will develop.

The blood supply to the fragments is good and firm bony union is usually the result, especially in young patients. Marked thickening, due to callus, usually will persist in the region of the trochanters ; in elderly people there is a risk to life (see p. 496).

If union is unduly delayed, or non-union results, then operation must be undertaken provided the patient will stand it. A hole is bored through the top end of the shaft and a Smith-Peterson pin or an autogenous peg, cut from the fibula or tibia, driven through the shaft into the neck of the femur.

(*b*) **Intracapsular,** *i.e., through the narrow part of the neck of the femur.* This latter term is perhaps preferable to the old name intracapsular, although this particular injury is usually entirely intracapsular; rarely over the posterior part of the neck the fracture is extracapsular at some point. The major portion of the fracture lying within the joint capsule, it follows, therefore, that synovial fluid has free access to the fragments, while the blood supply of the head is precarious.

This fracture usually occurs in the elderly, especially in women, and as a result of trivial violence; it is often caused by catching the foot in the edge of the carpet. The atrophic femoral neck gives way readily, and impaction is uncommon unless the fracture occurs with the limb in abduction. The poor blood supply to the loose upper fragment, combined with the presence of synovial fluid, explains the frequency with which non-union is met in these cases. Often the only connection left between the two fragments are the cervical ligaments of Stanley, and it is important not to rupture these by rough movements during examination.

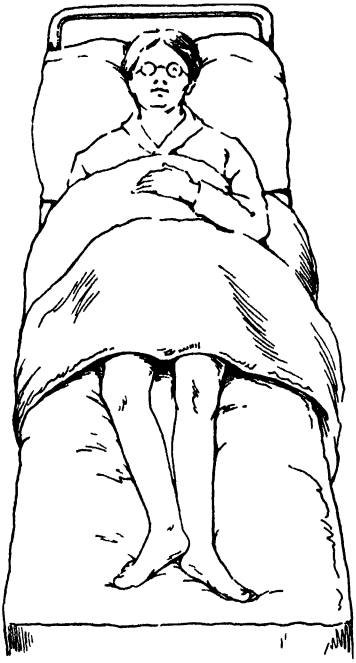


FIG. 241. Eversion of the foot and shortening typical of an intracapsular fracture of the neck of the femur.

Two types of this fracture are recognised :—

(1) The commoner adduction fracture which occurs in about 80 per cent. of cases, with raising of the trochanter and external rotation of the limb—which is slightly adducted and flexed. This type of fracture contributes some 80 per cent. of the intracapsular fractures of the neck of the femur, and is seldom impacted. Unless this fracture is accurately reduced and suitably and rigidly fixed until bony union occurs, fibrous union with a false joint and loss of function will ensue.

(2) Abduction fracture is far rarer, and occurs in only 20 per cent. of cases. Impaction is nearly always present, the limb being slightly inwardly rotated and abducted, and the trochanter lower than normal. In this variety impaction is the rule and the patient may walk on the limb, but should be discouraged from attempting this. In this type of fracture bony union nearly always occurs, and great care must be taken not to disturb the impaction.

X-ray films should, of course, be taken in either case to confirm the type of fracture sustained.

In the common, non-impacted case the limb is rendered helpless.

Clinical Features and Diagnosis. Although this fracture is undoubtedly often pathological, secondarily to absorption of the bone in the femoral neck, there is as a rule a definite history of an injury, however trivial, followed by inability to use the leg, which is held externally rotated and may be adducted or flexed, though infrequently the patient may have walked on the limb after the fracture has occurred; crepitus is usually absent and should not be sought for. True shortening is present, from a half to one and a half inches, while the great trochanter is raised and less prominent than usual, and the iliotibial band is slack. As a rule pain, bruising and shock are not well marked, though tenderness will be detected over the fracture. As this fracture occurs as a rule in the elderly, the possibility of its being a pathological fracture, secondary to such conditions as carcinoma of the breast or prostate, should never be lost sight of (Plate V.).

It must be remembered that in elderly people with osteoarthritis, eversion and shortening of the leg may be present; there is, however, no relaxation of the iliotibial band.

Treatment. If the condition and the age of the patient are such that it appears likely immobilisation in bed will be tolerated, treatment should be carried out on exactly the same lines as given for fracture of the broad part of the neck, *i.e.*, immobilisation in plaster of Paris in extension, internal rotation and abduction as advocated by Royal Whitman.

If it is thought that the patient can stand an anæsthetic and operation, a *Smith-Petersen* pin may be driven through the trochanter, through the neck and into the head of the bone, with the limb fully inverted and extended. This method has largely replaced the older operation where a fibula bone peg was cut and driven into the head of the bone. Following this operation no splint is necessary, and the patient is allowed to move about in bed, and to move the leg freely.

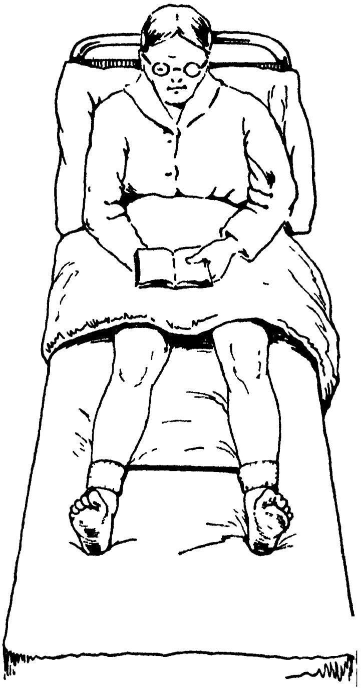


FIG. 242. Plaster bands and cross bar applied after reduction of a fracture of the neck of the femur. (Sound leg traction.)

The results of this procedure are good, though it is a risky operation in a feeble elderly patient. The patient may be allowed out of bed in a walking caliper splint at the end of two weeks, but no weight should be borne on the limb for at least a month. Further, though bony union may occur in the early stages, and frequently does so, it is not uncommon for this bone to be absorbed at the end of six to nine months, in which case further operation is not advisable.

It is not usually necessary to remove the pin, but should the patient complain of pain, or the neck of the femur slip, the pin can be extracted easily. Should the fracture fortunately be impacted every effort should be made to avoid disimpaction, and in this case there is good chance of union. After a few days (or as long as posible) in bed the patient is got into a chair and massage and gentle movements are given to the limb.

If, however, the patient is very feeble and old (and this is so in a great many cases) no operation will be advisable, and a method, which gives excellent results and has been used for many years in Edinburgh, is to correct the deformity by extension and inversion of the joint combined with traction, and then to secure the limb in slight abduction by a plaster band passed round the leg and fixed by an iron bar to a similar band on the opposite leg (sound leg traction) (Fig. 242). This enables the patient to be nursed easily and to sit up and move about in bed.

Prognosis and Results. Such an injury in an elderly patient is accompanied by considerable risk to life, many cases dying within a few days from general debility and shock, or later from pneumonia, bedsores and sepsis.

Osseous union may be looked for in from 60 per cent. of these cases, and is more likely to occur when impaction of the fracture is present. As already stated, bony union may be present in the early stages and subsequently be re-absorbed, in which case, as when fibrous union occurs a false joint forms, the neck of the bone becomes absorbed and rubbed away, and the head comes into more or less direct contact with the shaft. Marked osteoarthritic changes will also occur. When union fails there will be marked permanent shortening and stiffness of the limb ; the pain largely will pass off, and the patient probably will be able to walk again ultimately with a limp, with the aid of one or two sticks.

Fracture of the Femoral Neck in Children. This injury is occasionally seen ; it is most often of the greenstick variety, and follows a fall or twist. The patient often can walk in spite of it, and the condition is therefore liable to be regarded as a bruise or sprain. An X-ray film, however, will show the injury, while the limb is found to be about half an inch short and slightly everted.

The deformity should be completely corrected under an anæsthetic and the limb put up for twelve weeks in wide abduction and inversion in plaster of Paris (see p. 492). If not efficiently healed before weight is borne it is very liable to be followed by traumatic coxa vara or Perthes' disease (see p. 545).

Fracture of the Head of the Femur. This is not common, and is usually a chip or crack associated with a dislocation of the hip, similar to that seen in the humeral head in a dislocated shoulder.

(2) **Fracture-Separation of the Epiphysis of the Femoral Head.** This epiphysis lies entirely within the joint capsule. It is occasionally separated completely by a sudden violent injury, in which case the condition closely resembles a fracture through the narrow part of the femoral neck (see p. 494), but more commonly it consists only in a partial slipping or separation of the epiphysis. This variety occurs especially in adolescents and children aged from ten to fifteen years, and often as the result of trivial injuries and strains ; it often, therefore, is only the later effects of the injury that bring the patient under our notice, as the coxa vara resultant on the weakening of the epiphyseal junction only develops gradually from the weight of the body during standing. The lesion may be produced by direct or, more commonly, indirect violence, and as a result the head of the bone is displaced downwards and forwards. If not reduced and treated immediately, the condition of traumatic coxa vara develops and increases insidiously (see p. 679). It is seen as a rule in males from eight to eighteen years of age, and the history is one of indefinite pain in the hip or knee with a gradually increasing limp. The condition may date back to some trivial injury, or occasionally the injury is much more definite and the condition approximates to the ordinary fracture met with in adult life.

Clinical Features and Diagnosis. Locally the signs are slight, but there may be tenderness in Scarpa's triangle. The limb is adducted, flexed and externally rotated, some muscular spasm being present, and internal rotation and abduction are limited. True shortening, with raising of the great trochanter, are present, but only about half an inch in extent, though this may increase later as coxa vara develops, with an increased adduction and external rotation of the limb. The X-ray appearance is typical.

Treatment. Reduction should be effected as soon as possible by long-axis traction under an anæsthetic, the limb being first abducted and internally rotated. Some surgeons advocate extension with the limb in the adducted position, and claim that the functional results obtained by this method are far superior. While under extension a plaster is applied on the lines already laid down. The limb should be in a position of 40 degrees abduction, 20 degrees flexion, and full internal rotation. The plaster should be retained for two months, then removed, and massage and movements given in bed for a further fourteen days. The patient may then be allowed up on a walking caliper splint, which should be worn for six months. Even after this has been discarded finally it is well to examine the patient periodically for the onset of coxa vara. In old-standing cases, where coxa vara is well established, efforts at reduction by manipulation are useless, and we must aim at preventing increase of the deformity by fitting a walking caliper. If gross deformity with marked limitation of abduction is present, subtrochanteric osteotomy is indicated (see p. 716).

(3) (*a*) **Traction-Fracture of the Lesser Trochanter.** This rare fracture is produced by muscular violence, the bony process being detached by the iliopsoas. The diagnosis is reached by a consideration of the history, X-ray examination, the pain in Scarpa's triangle, and the presence of *Ludloff's sign*, *i.e.*, inability to flex the thigh in a sitting position.

The *treatment* consists in immobilising the leg in plaster in full internal rotation, with 70 degrees of flexion at the hip joint, for twenty-one days. After this massage is commenced, and the patient may be allowed to walk in one month, full use of the leg being allowed in six weeks. Fibrous union is the rule, but the results are good.

(*b*) **Fracture of the Great Trochanter.** This is rare except in association with fractures of the neck (see p. 491). It may occur, however, from a direct blow on the trochanter or from muscular action. The bony fragment is displaced backwards and the hip appears to be broadened. The epiphysis of the trochanter is occasionally pulled off. It is usually possible to keep the fragment in position by abducting the limb widely; if not it must be pegged or screwed into position.

FRACTURES OF THE SHAFT OF THE FEMUR

These may occur in the upper, middle or lower thirds. In the case of adults the treatment varies materially with the site of fracture, but in the case of the young subject they are all amenable to the same standard treatment. Fracture of the shaft occurs not infrequently *in the newly-born*, and in that case is best treated by binding the legs to the belly, with complete flexion of the hip and extension at the knee. Union takes place rapidly, and fixation may be discarded after fourteen days. Any slight deformity that may be present will be compensated for by growth later on.

These fractures, often the result of direct violence, are becoming increasingly frequent as the result of motor accidents. There is a history of great trauma, and the thigh is much thickened from effusion of blood, shortened and often grazed. The lower limb is useless, angulation present at the site of fracture and the limb below this point everted; any attempt to move, of course, causes great pain. In addition, there is usually marked collapse.

In very young children, that is to say of one to four years of age, Bryant's suspension method (Fig. 243) gives good results and renders nursing easy. The patient is slung by the feet to an overhead gallows, with the legs extended and the hips flexed to a right angle, so that the buttocks swing just clear of the bed. A word of warning should be given, as sympathetic attendants are apt to place a pillow below the buttocks, thereby vitiating the whole treatment, as the pelvis and body weight form the counter-extending force.

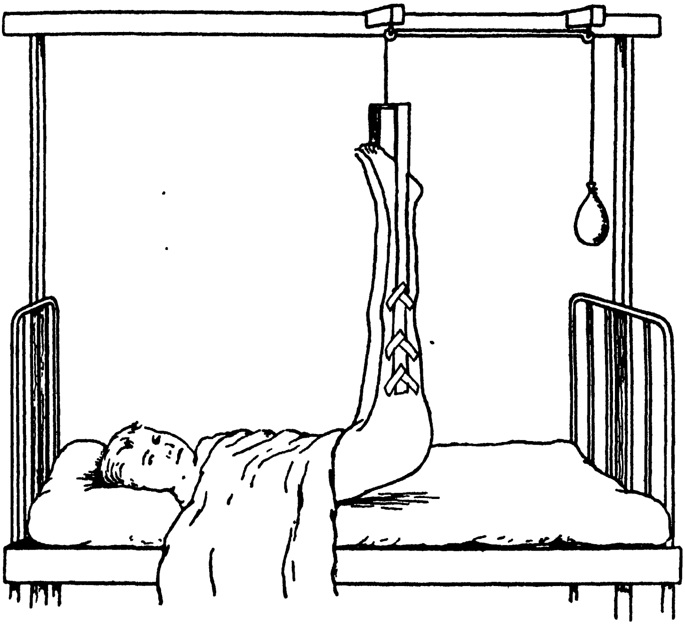


Fig. 243. Bryant's suspension method.

In older children and young adults fracture of the shaft of the femur is best treated in plaster of Paris, applied while extension is being exerted. Such a plaster must obtain a good grip round the pelvis and above the condyles of the femur, the points between which extension is exerted. Good position is readily obtained, and once obtained can be maintained without repeated adjustment. Young subjects tolerate this immobilisation well, and joint stiffness and muscle wasting do not arise in the same way as in the adult. It should never prove necessary to have recourse to operation for fracture of the femur in the young subject. The plaster is worn for six weeks to two months, then removed and the patient allowed to move freely in bed for ten days. After this time he may be allowed up on crutches, after fitting a patten to the boot of the sound side.

The crutches should be retained until union is firm and there is no risk of angulation occurring. During this time full active movements, without weight bearing, are encouraged. A walking caliper can be used, but, at any rate in the hospital class of patient, is too expensive to warrant its use for the short time necessary.

In the case of adults we have the serious difficulties of muscular wasting and joint stiffness to contend with ; therefore these cases are best treated on skeleton splints, which admit of access for massage and electrical treatment.

Kirschner's wire or Steinman's pin is by far the best method of obtaining satisfactory extension and seldom fails, as is so commonly the case with strapping or less often with an Unna's paste casing.

Should reduction by extension fail, as in these cases it occasionally does, recourse must be taken to open operation. Plating, or intra-medullary pegging, is the most satisfactory general method of fixing the fracture, and spinal anæsthesia may be used to produce complete muscular relaxation. The disadvantages of operation are the inevitable delay in union which results, necessitating longer immobilisation and the serious risks of angulation with resultant deformity. The usual method of approach in these cases is by an antero-lateral incision through the muscular planes. As no important structures are in the way, the approach is relatively avascular and the bone close to the surface. For spiral fractures Adams' clip is a useful alternative to a plate.

In children these fractures unite well and rapidly, especially the spiral variety. In adults union takes longer, and, as stated above, wasting and stiffness take a longer time to recover from. This is especially marked in cases subjected to operation. In the case of compound fractures treatment is carried out on the general lines laid down on p. 432, and special splintage adopted, depending on the site of the fracture. If sepsis supervenes, treatment proves particularly difficult, as efficient drainage is difficult to obtain, and extensive necrosis is likely to occur. Fibrosis and adhesions of the surrounding muscles are particularly well marked.

Fracture of the Upper Third of the Shaft. This fracture usually occurs just below the lesser trochanter and may be produced by either direct or indirect violence, while the fracture itself may be transverse or spiral, usually the former. Displacement is always present, and gives rise to difficulty in treatment. The short upper fragment is flexed, abducted and externally rotated by the iliopsoas and rotator muscles, while the lower fragment is pulled up and adducted by muscular action and rotated outwards by the weight of the limb. The resulting clinical signs present will be abnormal mobility and angulation at the site of fracture with shortening of the limb and external rotation of the lower fragment. Collapse may be marked.

Treatment. As it is almost impossible to control the short upper fragment, we have to bring the large lower fragment into line with it by flexing and abducting the thigh. Long-axis traction is applied under anæsthesia, with the knee flexed, and fixation then carried out. This is best obtained by fixing a strapping extension to the limb and then slinging it in a Hodgen's splint or better a Thomas's knee splint, bent to 145 degrees opposite the knee joint. Enough abduction must be given to correspond to the displacement of the upper fragment. The cords from the spreader of the extension should be turned up round the end bar of the splint and then carried over a pulley to a weight. This weight, in the case of an adult, 20 pounds, is applied while the muscles are still relaxed under the anæsthetic. After ten days it may be reduced gradually. The foot of the bed should be raised 12 inches on blocks to produce counter-extension, and the pelvis steadied by a perineal strap fixed round the crutch to the bed head of the opposite side. Tilting of the pelvis must be prevented by applying traction to the sound leg and fixing it on the opposite side of the bed. The splint should be slung from a Ba kan beam with a counterpoise weight. The limb is supported in slings and, if necessary, the site of fracture is covered by Gooch's splinting to prevent angulation.

A similar effect may be produced by slings passed round the limb and one of the side bars of the splint, pulling on the fragments. Position may be checked roughly by measurement, but for satisfactory treatment a portable X-ray apparatus is imperative. By its aid we can check both the position and speed of union. Precautions must be taken against external rotation of the lower fragment and against foot-drop. The latter is controlled most easily by a vertical extension attached to the sole of the foot (Fig. 244).

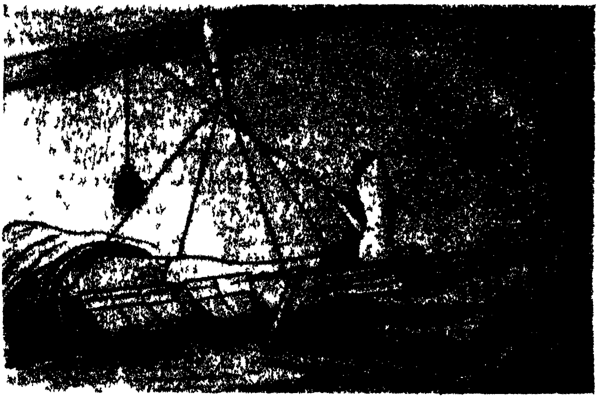


FIG 244. Counterpoise for foot-drop.

Massage, without disturbance of the fracture, may be given from the start, as may also faradism, to maintain the nutrition of the muscles.

Immobilisation should be kept up on an average for two months, but active movements of the ankle and toes may be commenced at once, and passive movements of the knee in a few days by means of the cord attached to the under-carriage of the splint, while active movements are usually possible in one month. After two months movements at the hip are commenced, the patient lying in the recumbent position, and he can be allowed up in a walking caliper splint. At the end of three months more the patient can usually be allowed to bear weight on the limb, walking with sticks for at least a month. Very often these times will have to be extended owing to delay in union. Union is checked by X-ray examination, as clinical examination proves deceptive; bowing at the site of fracture is prone to develop if weight is borne prematurely.

Fracture of the Middle Third of the Shaft. Fractures due to direct violence are usually transverse, but when due to indirect violence the line of fracture tends to be spiral, and comminution may be present. The displacement is variable, save that there is a constant tendency to backward angulation at the site of fracture, that is to say, obliteration of the normal anterior bowing of the femur. The upper fragment is as a rule slightly flexed and abducted, the lower adducted, drawn up and rotated outwards. The limb becomes quite useless and considerable overriding of the fragments usually occurs, with the result that there is marked shortening—usually 1 to 1½ inches;

eversion is marked, while the great trochanter will be found not to rotate with the shaft of the bone. The crepitus and abnormal mobility usually render the presence of a fracture obvious, but the great amount of swelling and effusion will render diagnosis of its actual site difficult. In many of these fractures, especially those low down, there will be an effusion into the knee joint; in some instances this is due to concomitant injuries, sprains, etc., of the knee, but it may be an indirect result of the presence of the fracture close by, and may be regarded as analogous to an œdema of the soft tissues around.

The most serious types are the compound fractures due to gunshot wounds.

Treatment. This is a difficult fracture to treat, and it is well to remember that in spiral cases at any rate a certain amount of permanent shortening is likely to result. Reduction is effected by long-axis traction under an anæsthetic, with the hip and knee in the position of extension. The deformity to be corrected is shortening and backward angulation. Besides pulling out the fragments, long-axis traction, by straightening the muscles within their sheaths, tends to push the fragments into position.

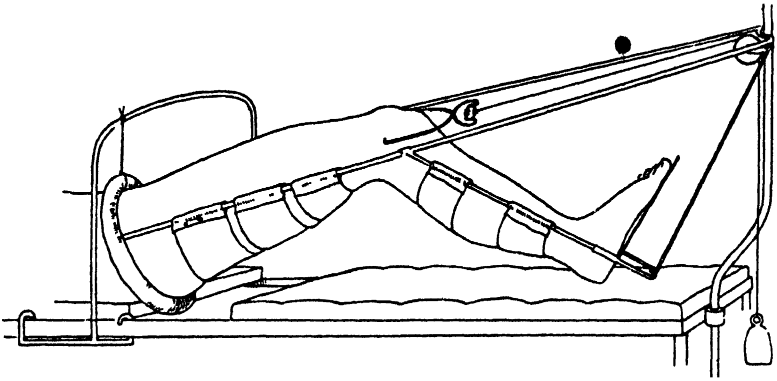


FIG. 245. Fracture of the lower third of the femur treated by extension with a pin and caliper. This could be done with a Kirschner's wire.

Kirschner's wire or Steinman's pin driven through the femur just above the condyles should be used as the routine method of applying the extension which when they are used need be only 10 to 15 pounds, as there is direct pull on the bone, and the limb supported in a skeletal splint (Fig. 245).

Proper immobilisation is most important. Thomas's knee-splint may be used with either fixed or sliding extension, but in the early stages of treatment at any rate the latter is the better. One great essential of this method is to see that there is a sling braced tightly behind the site of fracture, to prevent posterior angulation. The splint may be slung from a Balkan beam or supported on a foot-rest. The foot should point vertically upwards, both in the lateral and anteroposterior planes. This can be done by a foot-rest attached to the Thomas's splint (Fig. 244).

Immobilisation is carried out and after-treatment given as outlined for a fracture of the upper third. In this case movement of the knee may be permitted at the end of three weeks. This is most conveniently done by attaching a subcage to the Thomas's splint (Figs. 244, 245). By this means the knee can be moved daily through the requisite angle without interfering with the extension.

Fracture of the Lower Third of the Shaft. These fractures often result from direct violence, such as a wheel passing over the lower part of the thigh, so that considerable bruising or hæmorrhage into the knee joint may be present. The fracture is often comminuted, and abnormal mobility, shortening of the limb and angulation at the site of the fracture are marked. Collapse may be present. It should be noted that whereas in this fracture the lower fragment is pulled backwards, in a separation of the lower epiphysis (see p. 504), the epiphysis is displaced forwards. In either of these injuries pressure upon the popliteal artery or vein may occur. Even penetration of these vessels by a spicule of bone has been recorded.

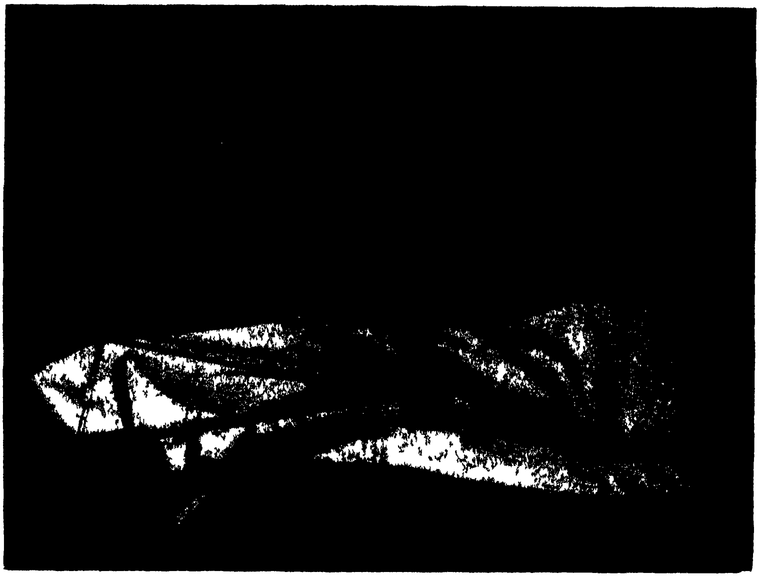


FIG. 246. Showing the principles enunciated in Fig. 245, in actual practice, combined with apparatus enabling the patient to move the knee.

Treatment. Here the troublesome deformity to be overcome is backward flexion of the lower fragment produced by the pull of the gastrocnemius; therefore this fracture must be treated with the knee well flexed. Reduction is effected by long-axis traction, the knee joint being flexed throughout. Immobilisation is carried out on a Thomas's knee splint bent to 40 degrees of flexion at the knee joint. A sling, to which particular care must be directed, must be placed under the lower fragment. In using Thomas's knee splint, if a large degree of flexion is necessary, two extensions may be applied to the leg. One runs straight off in the line of the thigh and carries the extending weight, the other fixes the leg below the knee in the splint (Fig. 245).

Generally in these cases traction by Kirschner's wire or Steinman's pin will prove necessary and these may have to be inserted through the tibial tuberosities so as to avoid penetrating the knee joint.

If backward displacement persists and union in this position occurs, great strain is thrown upon the knee joint, which will give rise to its ultimate disorganisation by chronic arthritis.

In fracture of the femoral shaft union is sometimes very slow and malunion and non-union are not uncommon. Fracture or bending within a few months of the original injury is sometimes seen to occur, even before the patient has started to get up. For this reason in many cases it is well to fit the patient with a "walking caliper splint" when he first begins to get about and to let him wear it for some weeks or months.

Operative treatment is called for occasionally in fractures of the femur, when the above methods have failed to correct the deformity or to prevent its recurring; it will be required also in non-union or malunion (see p. 431). It should, however, be remembered that proper extension by means of modern methods will pull out a great majority of these fractures into good position.

INJURIES AROUND THE KNEE JOINT

Fractures of the Lower End of the Femur. These must be regarded as serious injuries on account of the fact that they are liable to involve the knee joint and alter the line of weight bearing thereon; there is also a risk of damage to the popliteal vessels and nerves.

Supracondylar Fracture. This is usually seen in strong adults as the result of heavy falls; the fracture is roughly transverse and the displacement similar to that which occurs in the case of fracture of the lower third of the shaft (see p. 502).

Clinically it is found that much swelling occurs, while the knee joint is usually full of fluid and blood. Abnormal mobility and crepitus are marked, especially on flexing the knee. About 1 inch of shortening usually will be found, while the end of either fragment can usually be palpated in its abnormal situation. A careful examination should be made to see if the popliteal vessels and nerves are damaged. The full extent of the fracture is not likely to be revealed until an X-ray photograph is taken.

Treatment. This is rendered difficult by the small size of the lower fragment; thus flexion of the knee will usually be required. The treatment consists in traction by means of a wire or pin through the tibial tuberosities, the limb being supported in a Thomas's splint, bent if necessary. Operation may be required.

Fracture of the Condyles—T-Fracture. This is usually produced by direct violence. Either condyle may be broken off the femur, both may be broken off in one piece, or each may be broken off and they may be separated from each other, this last constituting a T- or Y-fracture into the joint. It is probable that this last occurrence is due to the condyles being both broken off first and then the upper fragment is driven between them and splits them apart down the intercondyloid notch. There is great swelling round the knee and marked effusion and hæmarthrosis in the joint; great broadening of the knee, with about 1 inch of shortening, will be present; at times the condyles may be felt to move upon each other with crepitus, while it is sometimes possible to feel the patella hitch against the line of the fracture on moving it transversely. This implication of the joint is almost certain to lead to some limitation of function.

There is risk of concomitant injury to the great vessels in the popliteal space, and if, as is usually the case, the fracture involves the knee joint, a very large hæmarthrosis occurs, and may be the cause of difficulty in treatment.

Treatment. Perfect reduction, with especial reference to the joint-line, is essential. Generally this can be effected by manipulation under anæsthesia, but, if not, open operation must be undertaken and the loose fragments pegged together. Reduction must be followed by efficient immobilisation, and this is effected in a straight Thomas's splint, with the knee in the position of extension with traction on the fragments by means of a wire or pin passed through the tibial condyles. Some cases will be seen where treatment with the knee in flexion is necessary to prevent displacement (see p. 501). Fixation may be discarded in six weeks, and active movements of the knee allowed in bed at an early date where a wire or pin extension is employed. After two months the patient may be allowed up on a caliper splint and may bear weight in three. Should the reduction be imperfect genu valgum or varum follows from displacement of one or other condyle.

Union takes place rapidly as a rule. Occasionally, however, in spite of massage and immobilisation, adhesions form in or around the knee joint.

Separation of the Lower Epiphysis of the Femur. This is a somewhat rare injury in patients under eighteen and occurs as a result of violent hyperextension of the knee; thus it may be produced by entangling the foot in the spokes of a wheel when riding behind a carriage. Some small portion of the diaphysis is usually torn off too.

The lower epiphysis is displaced forwards and the diaphysis projects backwards into the popliteal space. In an extreme case the fracture may become compound, and there are grave risks of gangrene from pressure on the popliteal vessels. A most characteristic feature of the injury is the appearance of the smooth end of the diaphysis in the popliteal space and the smooth, soft nature of the crepitus.

Treatment. Reduction is effected by traction and flexion; it may be difficult, and, if necessary, open operation should be performed and the leg immobilised in plaster with the knee flexed at an angle of 40 degrees. The plaster may be discarded in one month, after which massage and movement are carried out in bed for another month. After this weight bearing may be allowed.

In a severe case, with pressure upon the popliteal vessels and gangrene, primary amputation may prove necessary, and in all cases premature synostosis, with irregular growth, is likely to result.

Fracture of the Patella. This is a common injury usually seen in adult males, in whom it may be caused by direct violence, in which case it is usually *stellate* and comminuted and often without much displacement. It is more often produced by indirect muscular violence due to a sudden pull of the quadriceps; this occurs in attempting to avert a fall backwards, or by suddenly bracing up the quadriceps to prevent the knee giving way when it is flexed. The result is a *tranverse* fracture with separation of the fragments, as the bone is broken in the way in which one breaks a stick across the knee; cases have been reported in which the lesion was bilateral, both occurring at the same time. The amount of separation of the fragments varies greatly and depends upon how much the quadriceps expansion is torn; it may be anything between ½ inch to 3 inches.

As a result of the fracture power in the limb is lost and the knee joint fills up with blood and exudate. The periosteum of the patella is often torn at a different level to that at which the bone breaks and may hang down in the form of a flap between the two fragments and prevent union.

The fracture may be diagnosed by the bruising, which is always present, a line of maximum tenderness and the presence of palpable separation. X-ray examination completes the diagnosis. The patient cannot stand or extend his leg, while the two fragments may be moved backwards and forwards upon each other (Plate V.).

Treatment. 1. *Cases without separation* (*stellate fracture*). In this case, and also in the case of middle-aged or elderly people who do not lead a very active life, even if separation is present there is no need for operation. The limb should be immobilised on a posterior gutter splint of metal or plaster of Paris, with the knee in the position of extension. Faradism may be applied and massage begun at once to the quadriceps, while at the end of a few days gentle movements of the knee may be started, the patella being supported with the fingers and moved gently from side to side, to prevent adhesions. The patient may walk in the splint during the whole of this period, but care must be taken that the support is not discarded too soon, otherwise refracture may occur. The splint may be discarded in six weeks and full use of the leg allowed in two months.

Some surgeons advocate complete removal of the patella for this condition. Though this operation may be followed by good movement and a fairly strong joint, the lower end of the femur and the knee joint are left completely unprotected.

2. *Cases with separation* (*transverse fracture*). In this case, and especially in young and active patients, operation is the ideal treatment and should be carried out at once provided the skin is not abraded. The skin should be cleaned thoroughly before the operation. Exposure is obtained by turning upwards or inwards a horseshoe-shaped flap of skin. The fragments should be turned back, their surfaces cleaned and the knee joint emptied of blood clot and effusion. The best means of fixing the fragments is by suture of the torn quadriceps aponeurosis only, but if this will not hold stitches, a kangaroo-tendon suture may be passed right round the bone. Alternatively the fragments may be drilled and a wire mattress-suture used. Care must be taken to obtain an even surface playing on the condyles of the femur, *i.e.*, accurate apposition of the fragments, as otherwise traumatic osteoarthritis will develop for a certainty; it is quite likely to set in in any case. The limb is immobilised on a gutter splint and after-treatment carried out as above. Cases that have been subjected to wiring must be treated more slowly than others.

If for any reason operation cannot be undertaken the leg is immobilised in extension on a plaster gutter or a straight Thomas's splint, with two horseshoe pieces of adhesive strapping pulling the two fragments together, and the after-treatment proceeds on the usual lines, but bony union is not likely to occur with this method of treatment as the fibrous aponeurosis remains between the fragments and prevents its occurrence.

Prognosis. The best functional results are probably obtained by means of operation, but very good and powerful limbs are seen in cases not operated on. One of the chief advantages of operation is that the joint can be cleared of blood clot and the aponeurosis cleared from between the fragments and sutured.

Good results are usually obtained; in cases with no displacement and those which are operated upon bony union occurs, but this is rare otherwise, and in most cases fibrous union only occurs. This need not interfere with a strong limb, though in some cases the fibrous tissue stretches after a time and the fragments come further apart which weakens the power of extension. Refracture some few weeks or months after either bony or fibrous union is by no means uncommon. The upper fragment sometimes becomes adherent to the front of the lower end of the femur, and this leads to much disability.

Old-standing Fractures of the Patella. Cases are not infrequently seen where as a result of imperfect treatment fibrous union, with a gap between the fragments of several inches, has occurred, and many of these cases have surprisingly useful legs and require no treatment. If much disability exists, however, operation will be necessary to bring the fragments together; this is conducted on the same lines as in a recent fracture, but it must be remembered that the quadriceps will be shortened and contracted, and there will be difficulty in bringing the upper fragment down; in some cases it may be adherent to the front of the femur, while it may be necessary to lengthen the quadriceps by making incisions across its fibres or by cutting and turning down a flap. If, for any reason, operation is impossible, a knee-cage will have to be worn to limit flexion and support the joint.

DISLOCATION OF THE PATELLA

This is a rare injury, which is predisposed to by laxity of the capsule or by genu valgum. The patella usually passes outwards, very rarely inwards. This injury may be produced by direct violence, in which case a complete or partial lateral dislocation results, while besides the lateral displacement there may be rotation of the patella in a vertical plane, the bone twisting round so that its edge rests on the front of the femur (vertical dislocation), or being turned completely over so that its anterior surface rests on the femur. More often it is due to the pull of the quadriceps acting on a leg in faulty alignment. This is especially seen in cases of genu valgum, and in these cases the dislocation is recurrent and chronic (see p. 685). When the injury occurs pain varies very greatly in amount, the joint is held firmly flexed, and the displaced patella can be seen and felt easily; the exposed trochlear surface of the femur is also palpable.

Reduction is effected by fixing the thigh, extending the leg, and manipulating the patella into position, and this is always easily done under gas. Considerable effusion will follow, and a splint should be worn for seven days, but massage and passive movements may be given from the start. Weight may be borne after fourteen days, provided that synovial effusion has subsided.

Recurrent dislocation is treated by operation, although it may be palliated by a knee-cage (see p. 684). Operation may take the form of:—

1. Supracondylar osteotomy, to correct the genu valgum and straighten he pull of the quadriceps. This is hardly sufficient by itself.
2. Transplantation of the tubercle of the tibia and the ligamentum patellæ nto the internal tuberosity of the tibia.
3. Plication of the inner side of the capsule of the knee joint. This is the old-fashioned operation, and is not satisfactory.
4. Transplantation into the patella or patellar ligament of the gracilis or sartorius tendon.

FRACTURES OF THE UPPER END OF THE TIBIA

(1) **Fracture of the Head.** This is not a common fracture. It may be produced by a fall on the feet, and in this case it is impacted and combined with an impacted fracture of the head of the fibula. More commonly the head of the tibia is fractured by direct violence, and in this case one or both condyles may be detached and the knee joint involved. As a rule there is little displacement, except in oblique fractures, when the head slides laterally. Pain and swelling are marked, and an effusion always occurs into the knee joint, while the head of the bone appears broadened.

Treatment. Reduction, if necessary, is effected by traction and manipulation. If a condyle is widely separated open operation, with plating or pegging, may prove necessary. Immobilisation is best carried out by means of a pin or wire passed above or through the prominence of the os calcis, the limb being supported in a Thomas's splint, or in a plaster extending from the balls of the toes to the lower third of the thigh. If massage is available it should be applied in a few days, and to allow this, if a plaster has been used, the plaster should be bivalved, and the anterior half removed daily for massage. Passive movements of the knee can be commenced in twenty-one days, and fixation may be abandoned in six weeks and active movement commenced. The patient may be allowed up on a walking caliper at the end of two months, and may discard this at the end of a further two months.

This fracture resembles a fracture of the lower end of the femur, in that there is grave risk of subsequent stiffness in the knee joint, while in many cases it takes an abnormally long time to consolidate.

(2) **Separation of the Upper Epiphysis.** This epiphysis includes the tubercle and the facet for the fibula. Separation of it is very rare, but is sometimes seen under the age of twelve. The epiphysis is displaced sideways and forwards, and the lesion may give rise to arrest of growth, with shortening and angular deformity. It is treated on similar lines as (1), save that the caliper usually will be unnecessary.

(3) **Separation of the Tibial Tubercle.** This results from the traction of the ligamentum patellæ, and is met with as the result of jumping and violent strains in young subjects before the epiphysis has joined.

A subacute uni- or bi-lateral partial separation of this tubercle is often seen in boys under fifteen and is known as **Schlatter's Disease** (see p. 545). This gives rise to pain on using the knee, while there is a tender localised swelling round the tubercle. The X-ray appearances are usually characteristic, though they may resemble those of tuberculosis.

Treatment. If completely detached the lower fragment must be pegged into the tibia, and the leg is then immobilised in a plaster for three weeks, with the knee extended, and then passive, leading on to active, movements are commenced. No weight should be borne for six weeks. In Schlatter's disease complete rest for the knee in plaster of Paris for a month, followed by massage, usually will effect a cure.

(4) **Fracture of the Spine of the Tibia.** This may occur in association with rupture of the crucial ligaments, and is produced by gross twisting violence. All power in the limb is lost and the knee joint rapidly fills with blood, the further signs depending on which crucial ligament is damaged (see p. 512). The leg should be immobilised in extension on a straight Thomas's splint,

or in a plaster gutter, for six weeks. Massage and electrical treatment should be given from the start, and the effusion in the knee joint treated on standard lines.

INJURIES OF THE KNEE JOINT

Sprains and Contusions. A sprain consists of a tearing of some or all of the fibres of a ligament, and in the knee joint, as a result of wrenches and twists, this is very common indeed. Sprains are as a rule produced by indirect, more rarely by direct, violence, and the condition known as traumatic synovitis is set up as a result. Needless to say, this condition is an invariable associate of any injury or fracture involving the knee joint. All such sprains, whatever their cause, are associated with damage to some part of the capsule of the joint, and very often with more or less severe injury to the external or internal lateral ligaments. Intra-articular damage may be present as well, but this will be considered under a separate heading. Occasionally a small portion of bone is torn off with the damaged ligament (sprain-fracture).

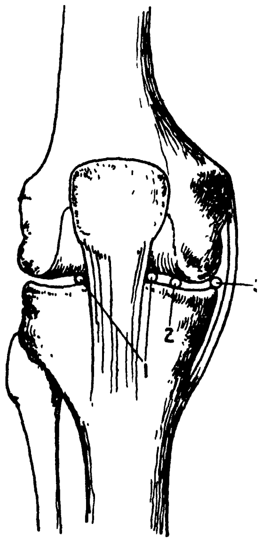


FIG. 247. Points of tenderness round the knee joint, (1) Bruised infrapatellar pad of fat. (2) Lesions of the internal cartilage. (3) Lesions of the internal lateral ligament.

Let us take for example a case of traumatic synovitis associated with strain of the internal lateral ligament. Following some injury causing a twisting or lateral deviation of the tibia, the ligament is partially torn near its insertion into the head of the tibia; the joint swells up, with effusion, and walking becomes painful or impossible. On examining the joint the characteristic signs of an effusion into its cavity are found (see p. 639), while there is tenderness over the attachment of the ligament to the tibia (see Fig. 247). Free fluid is present in the joint, as evidenced by fluctuation and the presence of a patellar tap.

Œdema and exudation are present in the periarticular tissues over the region of the injury, and these may be followed in some hours by extravasation of blood, while exquisite pain is felt on abducting the tibia on the femur. In the case of the external lateral ligament (much less commonly injured), all the signs will be on the outer side of the joint. If the condition is neglected, permanent weakness will result from overstretching of the capsule and ligament by the recurring attacks of synovitis. If the injury is severe, instead of a purely synovial exudate blood may be mixed with it in varying proportions (hæmarthrosis), and in this case there is a greater tendency for the formation of intra-articular adhesions or, at an earlier date, infection, with consequent pyarthrosis.

The differential diagnosis from a fracture or epiphyseal separation is made by noting that the most acute tenderness is over the ligament, that the bony points maintain their normal position, and that the movement which produces most pain is that which stretches the ligament; it should be confirmed by an X-ray picture. As will be seen later, in all injuries of this kind the position of the point of maximum tenderness round the knee is of great importance in diagnosis (see p. 509).

Treatment. The patient should be put to bed and a firm pressure bandage applied over the knee, while early massage and passive movement should be resorted to, and active movements with the patient recumbent encouraged after a few days.

Only where bone damage or internal derangement are suspected should a splint be applied, and then a posterior gutter splint with the knee in slight flexion is preferable to splints of a heavier type like McIntyre's.

Electrical treatment of the quadriceps and massage may be started at once, and after forty-eight hours the knee is strapped over a Scott's dressing.

Passive movements of the joint may be allowed in ten days, and active movements, without weight bearing, in from fourteen to twenty-one days, depending on the severity of the injury. Weight may be borne in twenty-one days on an average. Great care must be taken not to overstretch the damaged ligament, and in the case of the internal ligament, once walking is commenced, the inner side of the sole of the boot should be raised, as this throws the weight on the outer side of the foot and prevents stretching of the internal ligament.

If the effusion prove indolent, ionisation or a blister may be given with advantage. Where a ligament has been allowed to stretch and the joint has become unstable a knee-cage should be worn.

INTERNAL DERANGEMENTS OF THE KNEE JOINT

This is the name given to several different conditions which may involve the knee joint, and which in most instances are the results of injuries. In the traumatic cases there is nearly always, in the first instance, a sprain of the knee, complicated by damage to some structure within the joint. The various internal derangements may be classified as follows :—

1. Damage to the infrapatellar pad of fat and the ligamentum mucosum.
2. Damage to or displacement of the semilunar cartilages.
3. Rupture of the crucial ligaments.
4. Damage to the condyles of the femur, or articulating bony surfaces, with formation of traumatic loose bodies.

(1) **Bruised Infrapatellar Pad of Fat.** This injury results from nipping and bruising of the pad of fat which lies behind the patellar ligament and between the articulating surfaces. As a result a mild synovitis occurs, and the bruised portion undergoes swelling and thickening, with consequent fibrosis. Following this swelling it becomes more likely that it will be nipped again, especially during full extension movements of the joint ; and this is found to be the case, the knee showing recurring attacks of synovitis, brought on by sudden extension of the joint, and the condition constituting a vicious circle.

The maximum pain and tenderness are felt, and are to be elicited beneath the ligamentum patellæ, while the swollen and tender pad of fat usually can be felt as a small, painful swelling on either side of the ligament. Complete extension of the knee joint causes pain at this spot, as this squeezes the swollen and bruised structure. It must be remembered that in connection with the various forms of internal derangement of the knee the position of the point of maximum tenderness may be of great diagnostic importance. Thus in this condition the tender spot is under and at the sides of the ligamentum patellæ, in the lesions of the lateral ligaments the tenderness is over the ligaments at the lateral side of the joint (see Fig. 247), whereas in lesions of the semilunar cartilages it will be seen that the tenderness lies on the inner or outer side of the joint, as the case may be, and midway between the midline of the joint in front and the position of the lateral ligaments. Tenderness in the popliteal space is not likely to be due to lesions of the knee joint at all, but may be due to bone disease, inflamed glands, etc. A bruised retropatellar pad of fat exhibits a great tendency to pass into a chronic condition for the reason given above.

Treatment. In the acute stage, therefore, it should be carefully treated by absolute rest for a week, with the knee partly flexed; should the condition become chronic and recurring synovitis be established, it is best to fit a knee-cage, with a stop limiting complete extension, while raising the heel of the boot for one-third of an inch may achieve the same result. Operative interference, consisting in excision of the pad of fat, does not yield very encouraging results. Attention should be paid to the tone of the quadriceps muscle, and faradism be applied if necessary. The value of this is shown by the state of a patient who has been kept in bed for any length of time. On first rising pain is felt in the knee joints from nipping of the intra-articular fringes, due to the muscular wasting and consequent loss of stability in the joint, but this complication can be avoided by keeping the muscle in tone with suitable electrical treatment.

(2) **Injuries of the Semilunar Cartilages (Menisci).** Certain anatomical points in connection with these should be remembered. They are composed of white fibrocartilage, and deepen the articular surface on which the femoral condyles rest. The internal is the larger, narrower, more elliptic and more superficial; it is also attached to the internal lateral ligament and the capsule of the joint. The external is quite independent of the external lateral ligament, being separated from it by the tendon of the popliteus muscle; probably for this reason the external cartilage is rarely injured. Both are connected to the head of the tibia by the feeble coronary ligaments.

These cartilages are mobile to a certain small extent, as they slide backwards and forwards respectively when the joint is flexed and extended, and the internal one moves rather more than the external one. Moreover, the slight rotatory movement which occurs when the knee is slightly flexed is permitted by these cartilages sliding on the tibia; it will be seen also that any abnormal laxity of the ligaments of the joint will permit the cartilages an undue amount of mobility, and thus render them more liable to injury.

The two chief lesions which affect the semilunar cartilages are:—

1. *Tearing or splitting.* In the first instance this is due to a severe injury, but, once torn, recurring attacks are usually seen.

2. *Abnormal mobility*—again usually seen as the result of a severe primary injury.

Tearing and abnormal mobility are very frequently found to be combined.

The internal cartilage is the one by far more frequently affected (10 to 1), and the condition is more commonly seen in the left knee. It occurs most in young athletic men, especially footballers, or in miners, who kneel in a squatting position for long periods. This probably leads to a preliminary stretching of the ligaments (especially the internal lateral one), and so renders the accident more liable. When a cartilage is displaced the joint surfaces must be forced apart (as also occurs when the cartilage becomes jammed (see p. 511)), and this opening up of the medial side of the joint is nearly always accompanied by some tearing of the internal lateral ligament.

The actual damage which the cartilage may suffer varies much, the injury being produced by the articular surfaces of the femur and tibia being forced together and squeezing the cartilage. Thus a longitudinal split separating the anterior end of the inner half of the cartilage (so that this tag turns into the joint) is common—the whole cartilage may be split longitudinally into two (" Bucket handle " deformity), either end may be torn from its tibial attachments, or portions may become completely detached. The structure may be damaged by twisting violence, and in this case complete marginal detachment of the cartilage may occur. This latter injury is seen commonly in those who turn quickly on the toes while squatting with the knees flexed.

The cartilage, if partially displaced, occasionally may protrude outwards, but usually projects internally into the intercondylar notch. This is due to the fact that, as it moves backwards during flexion, the cartilage, being loose, gets caught between the femoral condyle and the tibia, and is forced further backwards and inwards ; in this abnormal situation it jams and blocks the movements of the knee. In most cases it is impossible to diagnose between a torn and an abnormally mobile cartilage.

Clinical Features. When the injury occurs intense sickening pain is felt over the cartilage, a crack may be audible, and the knee becomes fixed or locked in a position of slight flexion. The surgeon finds marked tenderness over the cartilage (see p. 508), and may be able to feel a small swelling there, while on manipulating the joint it will be found that, though it cannot be straightened, further flexion is possible. Traumatic synovitis rapidly ensues, with considerable effusion, and, if untreated, the cartilage ultimately may slip back into position or become adherent in an abnormal situation, forming a permanent bar to full range of movement. If the tear in the cartilage heals it does so by fibrosis. If part of the cartilage remains detached, as is usually the case, there is a marked tendency to recurring displacement with locking, followed by synovitis as the result of slight or unnoticed injuries, there being quiescent periods in between during which the knee is normal. It must be realised that, although the presence of " locking " is a valuable sign, its absence does not preclude the existence of a lesion of a meniscus, and it does not occur if only the posterior part of the meniscus is involved. Sometimes there is a click to be felt and heard at a definite stage during extension of the joint, especially if the patient is helping to move it with his muscles. Ultimately traumatic arthritic changes occur in the joint, and it becomes permanently unstable, with much muscular wasting.

In the acute stage the diagnosis is easy. The condition occurs with dramatic suddenness, and the type of violence, site of the pain, and locking of the joint indicate what has occurred.

The *treatment* consists in reduction of the displacement as soon as possible, if necessary, under nitrous oxide. The knee is further flexed and the tibia abducted on the femur by pushing on the lower end of the femur with one hand and grasping the ankle with the other. The tibia is then internally rotated and quickly extended, when reduction should occur, and a sharp click will often be felt. The after-treatment is the same as that of ordinary traumatic synovitis, while the patient must lie up for at least a week and take great care not to perform any twisting movements of the knee for some months.

Recurrent Lesions. Following an acute injury as above, the joint may recover completely, but more often there is a marked tendency to recurrent attacks, and in these cases we have to rely largely upon the history for our diagnosis ; if a typical history can be elicited, it is practically diagnostic. Such a history is usually one of attacks similar to that described above, but less severe, coming on after the slightest possible injury, and often preceded in the first instance by one severe injury, maybe years before, which was the *fons et origo* of the trouble. In addition to the pain, locking and effusion, it will be found that after several attacks the ligaments have become lax and the joint is unstable, while the quadriceps is markedly wasted and some fluid is always present in the joint.

This clinical picture may resemble closely that of a *loose body in the joint*, but in this case the locking is only momentary or lasts a very short time, it is absolute and does not permit of further flexion while it lasts, the pain will not be over either of the cartilages, there often will be no history of one severe injury in the past, and it may be possible for the patient or the surgeon to feel a loose body slipping about. On examining a patient with recurrent displacement of a cartilage there may be some tenderness on complete extension, and tenderness over the site of the cartilage, in which situation thickening may be palpable. Wasting of the quadriceps is always present, while an X-ray examination must be made, as this will exclude the presence of a loose body or of marked arthritic changes.

Treatment. If displacement has occurred more than once, it is best to remove the cartilage by operation (see p. 514). If for any reason the operation cannot be performed, a knee-cage limiting complete extension, with a pad over the cartilage, may be fitted. It is most important to give exercises and electrical treatment to tone up the quadriceps muscle, as the persistent weakness and wasting of the quadriceps which may follow any injury to the knee joint is in itself a source of great disability. It should be remembered that after removal of a semilunar cartilage, in most cases an almost exactly similar structure forms in its place which consists of fibrous tissue.

Lesions of the external cartilage are exactly similar, save that in this case there is a sense of pain and tension at the back of the joint owing to the attachment to the posterior crucial ligament, pain and tenderness are present on the outer side of the joint, and locking is not so well marked. Clicking in the joint is often complained of. They are rare injuries, the proportion being one external cartilaginous injury to ten internal ones.

(3) **Cysts of the semilunar cartilages,** particularly the external, are frequently met with. They are five times as common in the external as in the internal cartilage. They are not necessarily traumatic, though there is often a history of injury. They are found in the thick convex outer part of the cartilage, immediately beneath the fibrous capsule.

Clinically they fall into two groups: those that are noticed as cystic swellings along the joint line with no interference with function, and those that give rise to internal derangement of the joint, the cyst being discovered on the removal of the cartilage. It must be remembered that they are the only form of cyst which occurs actually on the joint line. Treatment, therefore, consists in removal of the cartilage in the majority of cases. The cartilage is often found to contain other small cysts: so that if only the cyst is removed and the rest of the cartilage is left behind, recurrence is likely.

(4) **Rupture of the Crucial Ligaments.** This is produced by violent twisting movements, and may be associated with fracture of the spine of the tibia. The clinical picture is one of very severe traumatic synovitis, and an X-ray examination may reveal a fracture of the spine. Later, when the condition is subsiding, it will be noticed that the joint is unstable, allowing abnormal displacement of the tibia on the femur, but owing to the severity of the initial effusion this point often escapes notice in the first few days. The

anterior crucial ligament is tight in extension, and therefore, if it is damaged, the tibia can be displaced forwards on the femur when the knee is extended; while the posterior crucial ligament is tight in flexion, and if it is damaged the tibia can be displaced backwards while the joint is flexed.

The *treatment* is that of traumatic synovitis, but the patient should be kept in bed for six weeks, while the leg should be placed in a plaster of Paris gutter and massage and electrical treatment commenced. No movement of the knee joint should be permitted for six weeks, and once the patient begins to get about it is well to fit a knee-cage. In the acute stage operation is useless.

In old-standing cases we have three alternatives:—

1. Fitting a knee-cage.
2. Performing arthrodesis of the joint, a fixed knee being preferable to a hopelessly unstable one.
3. Hey Groves' operation. In this operation holes are drilled through the femur and tibia in the requisite places, and the iliotibial band utilised for the manufacture of a new anterior crucial ligament and the semitendinosus for the manufacture of a posterior ligament.

(5) **Traumatic Loose Bodies.** There are many forms of loose bodies seen in joints; many of these are due to disease, such as osteoarthritis (see p. 633), or osteochondritis dessicans, but the truly traumatic ones are formed of bone and cartilage, and are produced by sharp blows on the articular cartilages, so that a piece of this with the underlying bone is at first partially, later completely, broken off. They are most commonly chipped out of the internal condyle of the femur by violence transmitted with the knee in a fixed position. Occasionally they remain attached to the parent bone by a pedicle of tissue. The old name " quiet necrosis " is both incorrect and misleading.

The symptoms and signs are those of an initial attack of acute synovitis, followed by attacks of intermittent locking and synovial effusion. The locking is usually momentary, and the patient can locate the site of the loose body with fair accuracy. Its position is variable, the body slipping about; hence the name of " Gelenkmaus." Often it is palpable to the patient or surgeon. Later on traumatic osteoarthritis develops, and the diagnostic picture is fogged by its presence; but in this case, again, we have a definite locking, indicating the presence of a loose body.

An X-ray film will show the loose body, and always should be taken. The diagnosis is reached on the history, taking into account the fact that locking is momentary, and not continuous, that when locked the joint can neither be flexed or extended, and that the site of the pain is variable (see also p. 511)

The *treatment* consists of removal by operation. If the body can be pushed into the suprapatellar pouch and steadied there, the surgeon can cut down upon it through a vertical incision. If it cannot be isolated the joint should be explored by splitting the patella, or, better, by an incision to the inner side of the patella, and dislocating this bone temporarily to the outer side.

(6) **Snapping Knee.** A few instances have been described of a loud painless snapping noise being made by a knee joint on movement, when the joint otherwise appears normal. The snap usually occurs at the extremes of movement. The condition is generally due to a congenital deformity of the external semilunar cartilage, which is circular, small in diameter, thickened and may be abnormally mobile. (*Congenital discoid cartilage*).

Treatment. Except in young children, in whom the snapping may disappear later, the cartilage should be removed by open operation.

OPERATIONS ON THE KNEE JOINT

As in all bone or joint surgery, the aseptic technique must be perfect. Before undertaking operation the skin must be prepared carefully on the lines laid down in Chapter I. After incising the skin the edges should be covered with pads or towels and a fresh knife used.

Operations may be carried out :—

1. Without a tourniquet.
2. With a tourniquet applied after the limb has been exsanguinated with an Esmarck's bandage. The tourniquet is not removed until the end of the operation and after the joint has been protected by a firm pressure bandage.
3. With a tourniquet which is removed as soon as the incision in the synovial membrane has been sewn up.

The method adopted is one of individual choice, but if a tourniquet is used, there is a risk of reactionary hæmorrhage into the joint and periarticular tissues, as hæmostasis depends on the continuous stitch in the synovial membrane and capsule, and on the pressure bandage. Again, the tissues are temporarily devitalised so that, should infection reach them, they fall a more easy prey.

The use of a tourniquet, however, gives a clean field of operation, and so renders the operation easier. Method (3) is a compromise, attempting to combine the good points of (1) and (2).

Where we wish to cut down upon a definite fixed structure, such as a cartilage or loose body isolated in the suprapatellar pouch, and are certain that we shall not want to investigate a larger field, an incision directly over the object in view is indicated.

Where a thorough exploration of the joint is necessary it is best to make a vertical incision and to dislocate the patella outwards temporarily, which is better than splitting it with a saw. The patella is hooked aside, the knee joint strongly flexed, and a good exposure of the inside of the joint thus obtained. At the completion of the operation sutures are put in to fix the patella back in its place and no disability results. After the operation the patient is put back to bed with his knee flexed over a pillow ; no splint is usually necessary, but a careful watch must be kept for undue embarrassment of the circulation by the pressure bandage, and in all cases this may be relaxed at the end of forty-eight hours. From this time onwards faradism of the quadriceps should be carried out every day, as it is most important to prevent any increase in the wasting of this structure and to attempt to build it up to its full strength.

After the stitches are removed the patient is allowed to commence active movements of the knee in bed, and is allowed up in a chair in ten days, while the knee should be held extended on a fracture board. After fourteen days weight may be borne on the leg, which should be supported with a firm bandage. Full movements and exercises are encouraged in a sitting position. After twenty-one days the knee may be used for walking for gradually increasing distances. Full use of the knee for vigorous exercise should not be allowed for three months.

If during convalescence effusion in the joint should become prominent we must proceed more slowly, and in a case where the patella has been dislocated or split the patient should be kept in bed for three weeks.

Operations for removing the Internal Cartilage. If it is absolutely certain that this is the structure at fault an incision over the cartilage as it lies on the head of the tibia should be made. A vertical or horizontal incision may be used. Care should be taken not to prolong an incision so far back that the internal lateral ligament is damaged. The joint should be flexed to open up the space for the surgeon, and this is best effected by having the leg hanging over the edge of the table, with the ham resting on a small sandbag. The surgeon sits facing the end of the table, with the sole of the patient's foot on his own knee, so that by rotating his own knee he can open up the joint without using his hands. An alternative method is to have the patient recumbent, with the knee flexed to 45 degrees over a large sandbag. If the diagonsis is doubtful, it is best to explore the joint by a vertical incision, reflecting the patella. If possible the whole, or at least the anterior two-thirds, of the cartilage, which generally includes the detached portion, should be excised cleanly. By the ordinary lateral incision it is extremely difficult, or impossible, to remove the posterior third. The anterior part of the cartilage is brought to the surface with a blunt hook, and, after detachment, special grasping forceps are placed upon it. By strong traction on these the cartilage is delivered into the wound and gradually cut away. The after-treatment has been described above.

In about five per cent. of cases the remaining posterior third of the cartilage causes further symptoms. It must then be removed by means of a separate incision further back opening the joint behind the internal lateral ligament. In some cases unsatisfactory results are seen from the development of a neuroma on the internal saphenous nerve, and the incision should be planned to avoid cutting this.

DISLOCATIONS OF THE KNEE JOINT

These are extremely rare, and can be produced only by excessive violence, usually of a twisting or rotatory character. An injury of sufficient violence to produce this condition is likely to be compound or to give rise to so much associated damage, such as a rupture of or pressure on the popliteal artery leading to gangrene, that amputation will prove necessary. Anterior, posterior and lateral dislocations have all been described. All these dislocations must be accompanied by complete tearing of the crucial ligaments.

Anterior Dislocation. This is the commonest form and is due to violent hyperextension. The limb is found to be 2 or 3 inches short, the patella is thrown forward, the patellar ligament is lax, and the skin over it wrinkled; the femoral condyles can be palpated behind while the leg is fixed in full extension. Pain and shock are very marked, while the injury is frequently compound.

Backward Dislocation is usually the result of the tibial head being forced back by a direct blow. This portion of the bone will be found lying in the popliteal space, with the leg rigidly hyperextended.

Lateral Dislocations are often incomplete; the tibial head is prominent on one or other side, while on the opposite side the femoral condyle forms a prominence.

Treatment. Reduction under anæsthesia should be performed, and the bones usually go back very easily, though the tendency to displacement is marked. The after-treatment is the same as for rupture of the crucial ligaments. In a few cases amputation will be necessary, *i.e.*, those cases which are compound, or where the popliteal vessels are injured.

Dislocation of the Superior Tibiofibular Joint. Cases of this condition have been recorded due to violent twisting movements or abnormal pull of the biceps tendon. The head of the fibula may pass forwards or backwards, and can be felt in its new position with the biceps tendon attached to it; the movements of the knee are free and more or less painless. The injury at times accompanies severe compound fractures of the tibia and fibula lower down. The dislocation is reduced readily, but tends to recur. A knee-sock should be worn for some time afterwards.

Total dislocation of the fibula at both ends has been described, the bone passing upwards as the result of severe wrenches to the foot and ankle.

FRACTURES OF THE TIBIA

(1) **The Shaft.** This may be broken transversely by direct violence or obliquely by indirect violence. In children the fracture is often of the green-stick variety, and the transverse fracture met with in adults is not infrequently subperiosteal, without displacement. On the subcutaneous surface of the tibia a tender spot is marked, and the irregularity can usually be felt. Swelling is severe and subcutaneous blebs are common. Crepitus may be present. An X-ray photograph is essential. Displacement, if it occurs, can be only of the nature of angulation, as the intact fibula acts as a splint, preventing

shortening. Reduction is, therefore, a case of adjusting alignment only (Plate VI.). Fractures through the lower part of the shaft are liable to delay in union due to damage to the nutrient artery.

Treatment. The limb should be immobilised by fixing it in a plaster extending from the balls of the toes to the upper third of the thigh. This is best retained for two months, but by some surgeons is bivalved in fourteen days, and massage, with passive movement of the ankle and knee, commenced, active movements being allowed at the end of three weeks. If the splint is retained weight may be borne and the patient allowed to walk in a few days, but if it is bivalved then exercises, such as those on the sliding seat, may be allowed in five weeks, and if an X-ray film shows good union, weight may be borne at the end of two months. In the case of children a plaster should be applied for three weeks and then changed for an ambulatory plaster. This may take the form of either an ordinary plaster, gripping below the tuberosities of the tibia, with a wooden sole incorporated at the bottom, or Delbet's plaster, gripping the tuberosities above and the malleoli below. This plaster should be retained for a month.

(2) **The Internal Malleolus.** This structure is sometimes injured alone, and this fracture may be regarded as the first stage of Pott's fracture. It has been described under the name of *Wagstaffe's fracture.* It is produced by inversion of the foot, and owing to the fibula remaining intact the mortice of the ankle joint is as a rule not seriously interfered with.

There is extreme tenderness and bruising over the line of fracture, with inability to use the foot. The line of fracture may be palpable. Crepitus is seldom obtained and an effusion occurs in the ankle joint. Diagnosis is usually impossible without an X-ray picture.

The *treatment* consists in applying a plaster up to the level of the tuberosities of the tibia for three weeks. The foot is in the natural position, that is to say, with the ankle joint at a right angle and the foot inverted. After removing the plaster the ankle is strapped, and massage and movements commenced. The patient is allowed to walk in six weeks, but the inner side of the boot should be raised and the heel " crocked." In the case of a heavy man weight bearing should be delayed a little longer, or an outside iron and T-strap worn for two months to prevent the development of flat foot. As union is usually fibrous, stretching will occur if strain is borne too soon.

FRACTURES OF THE FIBULA

(1) **The Upper Two-thirds.** Fracture in this situation is rare by itself, but may be produced by direct violence in the form of a violent blow on the bone. The possibility of injury of the external popliteal nerve must be kept in mind, while displacement is usually trivial and may be neglected. The diagnosis is reached by local tenderness, bruising and pain at the site of the fracture or on pressing the fibula lower down (fibular spring), and the result of X-ray examination. Twists of the extended foot are liable to crack this bone in its upper third.

The *treatment* consists in taking the weight off the leg by the use of crutches, and giving massage and movement from the start. Walking may be permitted as soon as it can be carried out without pain, which usually takes about three weeks. Alternatively, a plaster of Paris splint is applied as for fracture of the shaft of the tibia, and the patient can then walk from the first, though the splint must be retained for two months.

(2) **The Lower Third and External Malleolus.** A fracture in this situation is produced by sudden eversion of the foot. If we consider Fig. 248, we see that C is the most serious place for a break to occur, as the ankle joint is involved and the bone is unsupported; at the position B the strong inferior tibiofibular ligament acts as a splint, and at position D the fracture is, to all intents and purposes, a sprain of the external lateral ligament. At A the ligaments prevent gross displacement. A distinct crack may be heard at the time of injury, and on examination extreme tenderness is present over the line of fracture. Ecchymosis and effusion rapidly supervene, but there is no displacement or dislocation of the foot and ankle (Plate IV.). Should this latter occur, the case is one of *Pott's fracture* (see p. 520), when the treatment will be as laid down on p. 520.

Treatment. As regards treatment, fractures at A, B and D are treated by the application of a pressure bandage for forty-eight hours and immediate massage. After this the ankle is strapped and faradic treatment given to the muscles. The strapping should be retained for three weeks, but walking may be permitted at the end of ten days, provided the inner side of the sole has been raised. A fracture in position C is best treated by the application of a plaster for ten days. This plaster should extend from the balls of the toes halfway up the calf of the leg, the ankle joint being kept in the neutral position. Faradism of the muscles may be commenced at once by stimulating them above the level of the plaster. At the end of ten days the plaster is bivalved and massage and passive movements commenced, active movements being allowed in twenty-one days, and weight bearing at the end of four weeks.

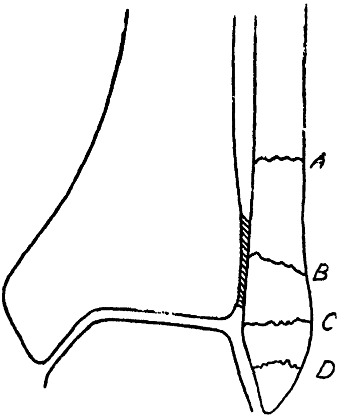


Fig. 248. Fractures of the lower third of the fibula.

FRACTURES OF THE TIBIA AND FIBULA

These are common fractures. They may be the result of direct violence, as occurs when the leg is run over or receives a heavy blow, in which case the line of fracture is transverse, and both bones are broken at the same level; or they may be the result of indirect violence, such as a fall on the leg or foot, or violent twisting, in which case the line of fracture is oblique or spiral, the tibia often breaking "en bec de flute." The site of fracture in the tibia is usually the junction of the lower and middle thirds, and in the fibula of the upper and middle thirds, while the line of fracture runs from above downwards and inwards, the lower fragment being displaced upwards and outwards. Displacement is usually marked, while it is the commonest fracture in the body to become a compound fracture.

The displacement is largely due to the weight of the foot and the traction of the calf muscles, while the fact that the tibia is largely superficial, and only covered by skin, renders it very likely that the sharp upper fragment of the tibia will stick through the skin and render the injury compound. It is also often comminuted, and sometimes a long fissure will be found running down into the ankle joint; often this will account for much pain and stiffness in the joint, though it is highly likely that the ankle joint will be sprained independently at the time of the injury.

Clinical Features. Marked pain, swelling and tension are present, while blebs and blisters in the skin are so common as to be almost diagnostic. The fracture is usually obvious on account of the deformity, abnormal mobility and crepitus, while on running the finger down the crest and internal surface of the tibia great tenderness and irregularity will mark the site of the fracture. The amount of abnormal mobility will indicate usually whether the fibula is broken as well or not; but "springing the fibula" (see p. 516) may help to settle this point.

Treatment. Reduction is effected by long axis traction and manipulation. The sooner this is done the better, as reactionary œdema beneath the aponeurotic sheath rapidly supervenes and forms an insuperable bar to adequate reduction. Full general anæsthesia and powerful extension are essential, while a Hawley table is the most convenient apparatus to use, pull being exerted on the foot by a felt or plaster boot (*cf.* p. 417). A careful watch must be kept for rotation of the fragments, and the inner side of the great toe, the internal malleolus, and the inner border of the patella should lie in the same vertical plane. The deformity that is particularly liable to elude reduction is posterior angulation at the site of fracture, and this is most likely to occur where undue efforts are made to dorsiflex the ankle joint to a right angle. In the case of this fracture it is not essential fully to dorsiflex the foot, and if this can be done only at the expense of angulating the fragments, the foot must be allowed to drop the requisite amount.

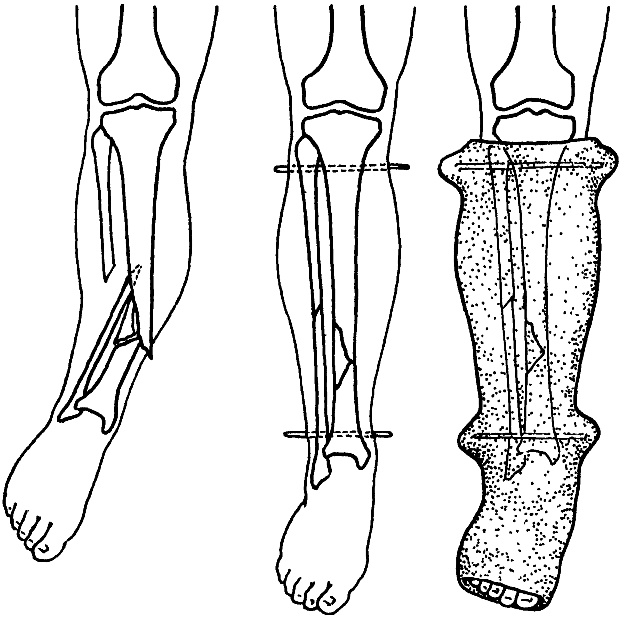


FIG. 249. Reduction and splintage of compound fracture of the tibia and fibula.

It will be found, however, that if the knee is slightly flexed good position of the ankle joint can be obtained. Provided that reduction of the tibia is perfect, the position of the fibula may be neglected; sometimes, especially in spiral fractures, and owing to the interposition of soft parts, reduction cannot be effected, and open operation, with fixation of the tibia, is the best procedure. If the fracture is low down, little control may be obtainable of the lower fragment, and this also may necessitate operation. If the case is seen after the development of reactionary œdema, and immediate reduction is impossible, it will be well to treat the case on a straight Thomas's knee splint, applying extension by a wire or pin through or above the os calcis, or better, through the lower end of the tibia. If after two or three days the fragments are not in good alignment, then wires or pins should be inserted through the tibia, just below the tuberosities and above the malleoli, and extension made between these two points either by means of a screw clamp or by weight extension in two directions. When good alignment and satisfactory position of the fragments have been obtained by this method, a plaster splint is applied with the pins *in situ*, the ends of the pins being protected with bits of cork or strapping. X-ray films are then taken to ascertain that the fracture is still in good position, and—if this is so—the pins can be withdrawn and the wounds dressed and incorporated in the plasters.

After reduction the leg is placed in plaster while the extension is still acting. The plaster should extend from the upper third of the thigh to the ball of the toes, and it is essential that it should be well moulded, gripping below, the tuberosities of the tibia, and above, the malleoli, the points of extension and counter-extension. It is the practice of some surgeons to incorporate in the plaster an accurately moulded posterior iron bar for the purpose of checking backward angulation, but this is seldom necessary. A careful watch must be maintained on the peripheral circulation in the toes, in case the plaster be too tight. Where double wire or pin extension is used, the plaster splint terminates below the knee, which can be moved at once. Very often it will be found that, owing to the subsidence of œdema after a week, the plaster is working loose, and in this case a fresh plaster must be applied. It is best to fix a walking iron stirrup under the foot, and the patient can walk at once, the plaster is then retained for from six to eight weeks (in transverse fractures often longer), *i.e.*, till X-ray films show good bony union, when the patient should be able to walk with a stick. Alternatively the plaster is bivalved after three weeks and massage commenced, movements of the knee and ankle being allowed a few days later, and if X-ray examination and clinical investigation indicate that union is progressing favourably, active movements may be commenced in five weeks, leading on to exercises on the sliding seat and fixed bicycle. After two months a walking caliper or double iron, with inside T-strap, may be fitted, and full weight bearing allowed in from three to five months. In the case of children immobilisation in plaster for six weeks, followed by the use of an ambulatory plaster for a further month, is the best line of treatment.

As regards end results, delayed union and non-union are often met with, especially in oblique fractures and those which are low down; these may require surgical interference ultimately, but usually all that is needed to effect bony union is reapplication of a plaster splint (which has been prematurely removed) and its retention till X-ray pictures show that bone is present. Each case should be taken on its own merits when deciding this point.

Compound fractures are most conveniently treated on a straight Thomas's splint, with extension applied to the foot, best by means of a pin or wire passed just above the posterior prominence of the os calcis. As soon as the wound is healed, or nearly so, a plaster splint will be found more convenient.

INJURIES OF THE FOOT AND ANKLE

Pott's Fracture (Fracture-dislocation of the ankle joint). In this we meet with an outward and backward displacement of the foot, due to a fracture of the fibula low down, together with fracture of the internal malleolus or tearing of the internal lateral ligament. It is found that, if eversion is the principal direction of the violence, the internal ligament ruptures and the fibula fractures through the external malleolus, while if abduction is the principal direction, the internal malleolus is fractured and the fibula gives way in the lower third of the shaft. As the two types of violence are, as a rule, combined, variable types of fracture result. The effect of the fracture is destruction of the mortice into which the astragalus fits, with widening and a tendency to outward displacement of the foot. As a result the weight-bearing alignment of the lower extremity is upset, producing in an untreated case a peculiarly painful type of stiff and flat foot. Very occasionally Pott's fracture may be produced by inversion instead of eversion.

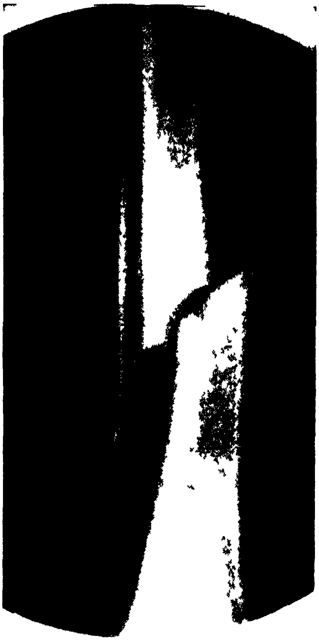
Clinical Features. The injury is often produced by slipping off the kerbstone or landing after a jump with the foot everted. In many cases the deformity is very slight and is unnoticed, while the patient may be able to walk, and the injury is regarded as a severe sprain. In more typical cases the deformity is marked and characteristic. The ankle becomes broadened, the internal malleolus unduly prominent, and the whole foot is markedly everted and displaced backwards, the toes pointing down towards the ground. Swelling, pain and ecchymosis are marked, as also are crepitus and abnormal mobility, while great tenderness is present over the site of the fibula fracture and over the tip of the internal malleolus. In the cases where there is no displacement the resemblance to a sprain is great, but the most marked tenderness is over the bone, and not over the ligaments, while an X-ray film, which should be taken in every case, will settle the point. In extreme cases the astragalus may be displaced completely behind the tibia.

Treatment. Reduction must be undertaken, if it is necessary, at the first opportunity, under full general anæsthesia. The first essential is flexion of the knee, as this slackens the tendo Achillis and allows the foot to come forward and move into the position necessary to secure reposition of the bony fragments. An assistant holds the flexed knee, and the surgeon, grasping the foot with one hand, strongly inverts and adducts it, while with the other he pushes forwards and pulls down the heel. If unassisted, the surgeon pushes back the leg with one hand and pulls forward the heel with the other. It should be pointed out that dorsiflexion of the ankle joint is not by any means essential to secure and maintain reduction, nor is it necessarily produced by pushing up the ball of the foot; this strains the midtarsal joints, but may leave the ankle joint unaffected.

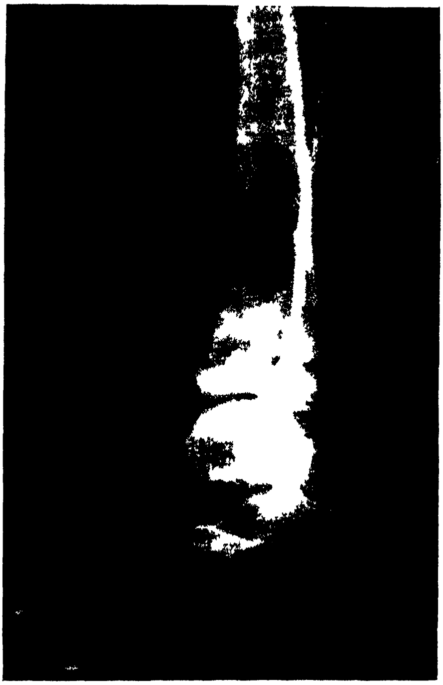
Dorsiflexion of the ankle is best brought about by grasping the posterior part of the os calcis and pulling it downwards and forwards, but should never be forced as this stretches the tibio-fibular mortice and tends to produce an unstable ankle joint. In some cases retention of the fragments in good position is possible only with the ankle plantar flexed; in this case no hesitation should be experienced in putting up the joint in this position, which can be corrected subsequently when the Unna's dressing is substituted and union has occurred.

After reduction the limb is padded and a plaster applied from the balls of the toes to the tuberosities of the tibia. Care must be taken that the foot

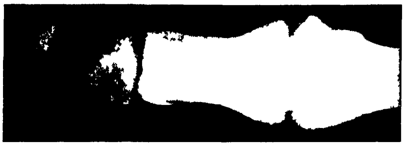
PLATE VI.



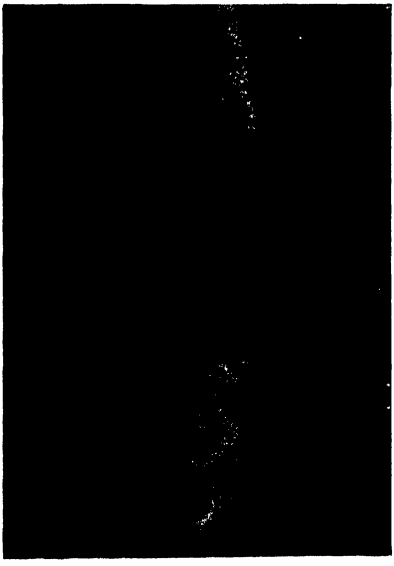
Fracture of the tibia and fibula.



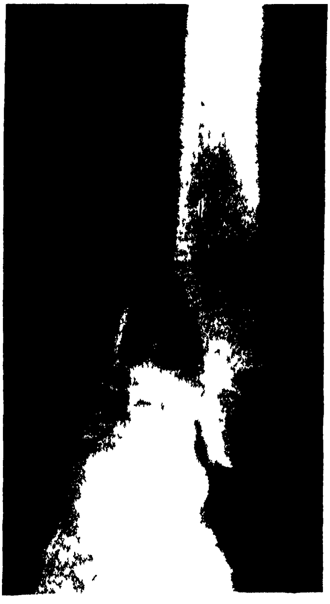
Fracture of the fibula.



Fracture of the terminal phalanx of the great toe.



Fracture of the fibula and displaced



Fracture of the tibia and fibula with gross displacement.

does not drop during the setting of the plaster, and a very careful watch must be kept over the peripheral circulation in the toes during the first forty-eight hours. A walking iron bracket should be incorporated with the plaster and the patient may get about with a stick in a few days. The knee and toes must be moved from the first. The plaster is retained for six weeks to two months, and is then removed and an Unna's dressing substituted, which should be removed every three weeks but worn for at least two months to prevent œdema of the foot and ankle. When weight bearing is allowed, the inner side of the sole should be raised and the heel crocked or an arch pad worn. In heavy men it is well to fit an outside iron and inside T-strap for six months, to prevent any development of valgus deformity.

If correction of the displacement cannot be obtained an extension should be applied by means of a wire or pin inserted above the os calcis, with the limb supported in a Thomas's splint; only if this fails to secure reduction will open operation be necessary, and the fragments will then have to be levered into position.

If perfect reduction has been carried out and weight is not allowed to be borne too soon, the results will be satisfactory; otherwise they will be disappointing to both the patient and the surgeon. Many very unsatisfactory results are seen, which could have been avoided by prompt and adequate reduction of the displacement.

Malunited Pott's Fracture. A malunited Pott's fracture produces very great disability due to pes planus, which is consequent on the unreduced deformity. In the early stages and in a healthy subject without joint disease the best treatment is osteotomy of the fibula, followed by wrenching of the foot into good position; in other words, the original fracture is reproduced, and the further treatment is as given above. In old-standing cases, where operation will be tolerated well and flat foot is absent, an arthrodesis of the ankle joint should be carried out. In feeble subjects, or in those cases where marked flat foot with arthritic changes is present, the fitting of an outside iron and inside T-strap is all that can be done short of amputation.

Associated Fractures of the Tibia. Not infrequently Pott's fracture is complicated by a chip-fracture of the anterior or posterior lip of the tibial joint surface. The treatment is the same; but if, owing to blocking by the loose fragment, the foot cannot be manipulated into good position, open operation, with removal of the loose fragment, must be carried out.

Dupuytren's Fracture. By this is meant any fracture in which the inferior tibiofibular syndesmosis is broken and the mortice of the ankle destroyed. It is usually superadded to Pott's fracture. There is separation of the lower ends of the tibia and fibula, while the astragalus may be forced up in between these bones. Thus, in addition to the usual signs and symptoms of a Pott's fracture, there is very marked broadening of the ankle, and X-ray examination reveals the actual state of affairs.

The reduction and treatment are on similar lines to Pott's fracture, but if coaptation of the tibia and fibula cannot be obtained by manipulation, a peg or nail must be driven through to hold them together.

Separation of the Lower Epiphysis of the Tibia. This is a rare injury which occurs in children under the same conditions as Pott's fracture occurs in an adult. It is usually associated with fracture of the fibula, and may be regarded as the converse of Pott's fracture; there is a risk of premature synostosis, with subsequent irregular growth (Plate VI.). As the fibula will continue probably to grow normally, marked inversion of the foot will result.

The *treatment* is the same as that required for Pott's fracture.

Sprains of the Ankle Joint. These are exceedingly common. The lesion consists of a tear of a part or a whole of the lateral ligaments, usually the external one, from sudden inversion or eversion of the foot. If it be the external ligament that is ruptured, any one of its three divisions may be torn alone. In these injuries there is intense pain and a feeling of cracking or tearing when the injury takes place; marked swelling, effusion and ecchymosis occur, but there is no bony deformity, no crepitus or abnormal mobility. Any movement which tends to stretch the damaged ligament is by far the most painful, while it will be found that the points of maximum tenderness and effusion lie over one of the ligaments, and not over the bones. The injury leads to great disability for some time. We must emphasise again the necessity for X-ray examination in all cases.

The *treatment* consists in applying a firm pressure bandage for the first forty-eight hours. After this massage is commenced and the ankle strapped, the site of the sprain being protected by a pad of sticking plaster, while the strapping is applied so that the damaged ligament cannot be stretched. Thus if the external ligament is damaged, the foot is bandaged in eversion; if the internal, in inversion. Similarly, when walking is commenced, the appropriate side of the sole is raised. Weight may be borne, provided that the ankle remains strapped and a boot is worn, at the end of ten days. The patient should never be allowed to hobble about in a slipper, but, provided the ankle is well supported, early weight bearing is an advantage. In a mild case weight bearing can be allowed earlier, provided there is adequate support.

DISLOCATIONS NEAR THE ANKLE AND FOOT

Dislocations of the Ankle Joint. These are very rare unless accompanied by a fracture. The foot may pass backwards, forwards, upwards or to either side, but the last two forms of dislocation cannot occur unless a bone is also fractured. They may be complete, but more commonly are partial.

(*a*) *Forwards.* This is the result of severe dorsiflexion of the foot; it gives rise to marked deformity, the foot appearing elongated and the heel less prominent; the malleoli are nearer to the sole of the foot.

(*b*) *Backwards.* This is the least rare form, and is generally caused by severe plantar flexion; it gives rise to a foot which appears shortened, with an unduly prominent heel behind. The ligaments are torn, and the tendons around may be damaged also.

(*c*) *Lateral and upward dislocations* only occur in association with Pott's fracture, fracture of the tibia, or Dupuytren's fracture, and they are considered under the headings of these fractures (see pp. 520, 521). It is in connection with these fractures that dislocation of the inferior tibiofibular joint is sometimes seen.

Treatment. Reduction is usually easy, though an anæsthetic will be required. The knee and hip joints should be flexed to relax the muscles, when traction and counter-extension will reduce the dislocation; tenotomy of the tendo Achillis may help. A short plaster should then be applied for fourteen days, with the foot dorsiflexed, and at the end of this time massage and passive movements should be commenced. In three weeks the ankle may be strapped and weight bearing be permitted.

In a few cases operation will be needed to ensure reduction, while in compound cases amputation may be required.

Dislocation of the Astragalus Alone. This is a rare injury which is often compound; it is usually due to violent wrenches or to falling on the feet from a great height, and may be complete or incomplete, the bone passing forwards or rarely backwards when there is associated fracture of one or both malleoli.

(*a*) *Anterior.* This is usually due to severe plantar flexion, which squeezes the astragalus out of its mortice and forces it forwards and outwards, so that it lies under the skin on the cuboid bone. The foot appears shortened, and the front part of it is inverted and abducted. Marked swelling and ecchymosis occur, and the displaced bone may be seen or felt under the skin.

(*b*) *Backward.* This is a very rare injury, which is the result of severe dorsi-flexion. It usually can be diagnosed for certain only by means of X-ray films.

Treatment. Reduction under anæsthesia must be attempted either by manipulation or, failing this, by open operation. Even open operation may fail to reduce the bone, and in this case the astragalus should be removed. The after-treatment is the same as that for dislocation of the ankle, but the results are not good.

Subastragaloid Dislocation. This is a rare injury, the os calcis and scaphoid, with the foot, being carried away from beneath the astragalus, which remains in its socket. The lower portion of the foot usually slips backwards and inwards, sometimes backwards and outwards. In either case the foot is shortened and the heel rendered unduly prominent, while the head of the astragalus can be felt projecting on the dorsum of the foot, and the external malleolus becomes unusually prominent.

This injury, in common with dislocations of the astragalus and the mid-tarsal dislocation, described below, is usually seen as a result of riding accidents, the fore part of the foot being caught in the stirrups. An X-ray photograph always should be taken.

Treatment. If possible, reduction should be accomplished under an anæsthetic, and then the after-treatment is the same as that for dislocation of the ankle. If this fails, astragalectomy may be required. In compound cases amputation is often necessary.

Mid-tarsal and Tarsometatarsal Dislocations. Both of these injuries are rare; in both of them the front half of the foot is usually displaced in a plantar direction, and the arch of the foot disappears. These injuries are often accompanied by a fracture of one or other of the tarsal or metatarsal bones. Reduction under an anæsthetic is usually easy; it should be followed by the foot being encased in plaster of Paris for fourteen days, after which the usual massage and movements can be applied.

Operation is hardly ever necessary except in compound cases.

Dislocation of the Toes. Dislocation of either the interphalangeal or metatarsotarsal joints are rare; they are easily reduced by traction and require little after-treatment.

FRACTURES OF THE TARSUS AND METATARSUS

These form some of the most crippling injuries with which we have to deal, the associated damage to the tarsal joints and upset of the normal mechanism of the foot giving rise to prolonged and tedious convalescence, or even permanent disability, while severe arthritic changes always supervene.

(1) **Fracture of the Astragalus.** This bone may break either through the body or the neck.

(*a*) In the case of a fracture of the body the injury is produced by falls on the feet, the bone being crushed, so that it tends to be comminuted and impacted. If comminution is not present and the fragments are in good position, there is a fair chance of recovering a normal ankle joint. The diagnosis is almost impossible without an X-ray film, but care must be taken not to mistake the os trigonum tarsi or fragmentation of the bone for a fracture.

The joint should be immobilised in plaster for three weeks and massage and movements then commenced. No weight should be borne for three months. If much comminution is present it is more than likely that a fixed joint will result in any case, and immobilisation is therefore maintained for two months. If gross displacement is present an attempt should be made to get the fragments into good position and obtain a fixed ankle joint. If any particular fragment defies reduction it will have to be replaced or removed by operation, but removal of the whole bone is not advised, as this seldom leads to good results.

(*b*) Fractures of the neck are generally transverse ; they are due to the same causes and do not involve the ankle joint. The foot should be immobilised in plaster for three weeks and weight bearing allowed after two months. When weight is borne an arch support should be fitted.

(2) **Fracture of the Os Calcis.** In this bone we also meet with two common types of fracture, though as many as eight varieties are described by Böhler.

(*a*) The tuberosity or the posterior portion may be broken off by the pull of the tendo Achillis, an instance of traction-fracture. The fracture is usually obvious, as the fragment may be pulled away for an inch or two, though the patient may be able to walk. Operation is the best line of treatment, and the fragment is nailed in good position after turning down a flap of skin ; in some cases this may be done through the skin. During the after-treatment the knee must be kept in the flexed position and the foot kept plantar-flexed. A short plaster should be applied for three weeks and the leg muscles treated with faradism.

(*b*) More commonly the body of the os calcis is fractured, and this is usually caused by falls on the feet. Such fractures are generally comminuted and not infrequently bilateral. They are always followed by troublesome arthritis of the subastragaloid joints and the development of painful spurs on the under-surface of the bone. There is usually a longitudinal fissure through the bone, and secondary cracks and fissures radiate from it in all directions, while the bone may be badly crushed and flattened ; it may feel even as though it were pulped, though crepitus is usually absent. There is great pain on movement and walking, while the foot may appear flattened and the heel broadened. Many cases are not diagnosed until an X-ray photograph is taken.

Treatment. In slight cases the calcaneum should be moulded into position as far as possible under an anæsthetic, and the arch restored ; it should be fixed in plaster of Paris, after reduction of the deformity has been checked by X-ray examinations, and compared with pictures of the os calcis on the sound side. The plaster should be retained for six weeks ; on removing it an Unna's dressing splint must be worn for at least two months. No weight should be, or as a rule could be, borne before three months, and an arch support and double iron should be fitted to relieve some of the weight on the foot. In cases with severe displacement, or where the foregoing method fails to secure reduction satisfactorily, the method employed by Böhler of first moulding the os calcis into shape, by a special clamp apparatus, and then the insertion of two Kirschner's wires—one just above the malleoli and the other through the posterior part of the os calcis—may be carried out (Fig. 250). By means of a special clamp and traction apparatus, traction is made upwards and forwards on the malleoli wire, and somewhat downwards and backwards on that through the os calcis, so that the fractured bone is pulled back into shape.

A plaster of Paris cast extending from the tibial condyles above to the balls of the toes below, and in which is incorporated a walking stirrup in the heel, is then fitted, and the patient may be allowed to walk in a few days. The splint and pins are removed after approximately three months, and the patient may be allowed to walk occasionally, but no weight must be borne if it causes pain, in which case an Unna's paste dressing should be applied. An arch support must be worn for at least six months.

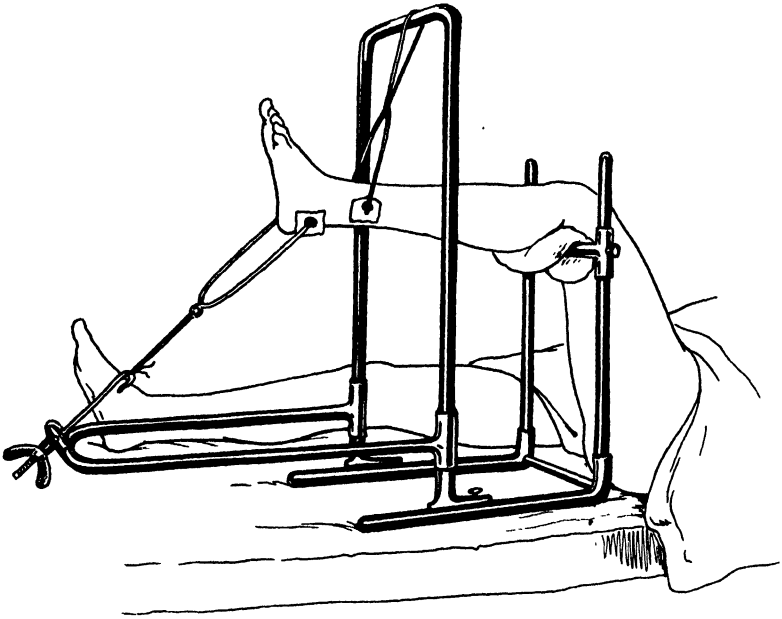


FIG. 250. Böhler's method of securing reduction in fracture of the os calcis.

The results of fractures of the os calcis have been very disappointing, and often severe pain persists, preventing the use of the foot and necessitating amputation. Subastragaloid arthrodesis should be tried in the first place.

(3) **Fractures of Other Tarsal Bones.** These are produced by direct crushing violence. Treatment proceeds on the lines given above, and special attention should be directed to supporting the arch of the foot when the weight is first borne.

Fractures of the Metatarsus and Phalanges. One or more bones may be broken by direct crushing violence, or occasionally one of the bones may break as the result of violent muscular movements or even while marching. (The latter condition was described in the base of the fifth metatarsal as a result of dancing or marching by Sir Robert Jones.) The fracture may occur in any part of the bone, but is commonest in the shaft just behind the head, while of necessity the transverse arch of the foot is damaged. This injury is often overlooked, as the amount of the swelling obscures the few signs of fracture which are present; crepitus and deformity are absent, but an X-ray film will always reveal the condition.

Traction on the head of the bone invariably causes pain if a fracture is present in the metatarsal bone.

Treatment consists in immobilising the foot by strapping the transverse arch over a felt pad placed in the arch. Massage and faradic foot-baths may be given from the start, while no weight should be borne for two months and an arch support should be fitted before walking is allowed. If the injury has been severe it is preferable to immobilise the foot in plaster for the first three weeks, after initial moulding under anæsthesia if necessary.

It is not uncommon to see a **Fracture of the Base of the Fifth Metatarsal,** presumably from traction of the peroneal tendons. This condition gives rise to much pain and localised swelling over the fracture, but no crepitus and deformity. Fibrous union results, and there should not be any permanent disability.

Marching fracture of the fifth metatarsal (see p. 525).

Fractures of the Phalanges. In these cases the toes should be strapped and no weight borne for ten days. In the case of a fracture of the great toe a metatarsal bar should be fitted to the boot and full weight bearing not be permitted for three weeks (Plate VI.).

CHAPTER XVIII

DISEASES AND TUMOURS OF BONE AND CARTILAGE

General Considerations. Before discussing the various diseases occurring in bone and cartilage it is essential to have a clear conception of the structure of their normal tissue, and furthermore to consider carefully the effect of the peculiarities of this structure on the processes of inflammation and repair when they occur as the result of trauma, infection or of neoplasms in these tissues. Every bone, irrespective of its shape or situation, consists of an outer shell of *compact bone* and an inner filling of *cancellous bone*, which varies much in extent in different bones, being very small in amount in the flat bones, where it is known as *diploë*.

The **structure of compact bone** is an important consideration in the understanding of the rapidly disastrous results of inflammation when this occurs. Such bone consists mainly of a series of concentric plates of bone tightly packed around the Haversian canals, and penetrated by fine channels radiating from these. There are two other series of plates, those filling the angular gaps between the various Haversian systems and those peripheral lamellæ which are arranged concentrically around the surface of the bone deep to the periosteum and are pierced at right angles by numerous canals conveying vessels from the periosteum to the Haversian canals through the concentric and intermediate plates.

Vessels, arteries, veins and lymphatics, which gain the Haversian canals, as above or from the nutrient vessels *via* the medulla, and nerves, mainly derived from the sympathetic system but also conveying sensation, are thus lying, among a little connective tissue, in canals the rigid bony walls of which permit of no expansion. Should, therefore, inflammation with consequent vascular engorgement and effusion occur, the vessels will become obliterated by the pressure of the perivascular fluid in the canals and, the blood supply being thus cut off, death of large tracts of infected bone occurs rapidly, while pressure on the nerves causes intense pain to the patient. Moreover, as the vessels are adherent to the bony walls of the Haversian canals, they cannot collapse, and hence infected clot is very liable to be carried into the circulation, this explaining the frequent occurrence of pyæmia in bone disease.

Cancellous bone is arranged in a series of trabeculæ within the shell of compact bone, with the inner surface of which it is directly continuous. These trabeculæ vary in their arrangement and density, which are determined in various situations by lines of stress and strain: they are divided into pressure and traction lamellæ, according to whether they are developed to strengthen the bone against the body weight or the pull of groups of muscles. The interstices between these bony processes are packed with bone marrow, yellow or fatty in the centre of long bones where the trabeculæ are few, and red or blood-producing at the ends of long bones and in flat bones where they are numerous. In this marrow run numerous vessels and nerves, which are prolonged in the Haversian canals and their radicles, and constitute the medulla of the bone. Inflammation in this medulla, therefore, produces effects more or less comparable to inflammatory processes in soft tissues, but, should it occur in dense cancellous bone, then extensive necrosis is likely to follow as in compact bone. The entire bone is surrounded by a dense sheath of vascular fibrous tissue, the **periosteum**, which is readily separable and distinguishable in the case of children but harder to demonstrate in adult bones. This membrane, to which muscles and tendons have intimate attachment, and which is adherent at the epiphyseal and articular cartilages of all bones, is traversed by numerous vessels which enter the canals in the peripheral plates of underlying compact bone, from which they are torn with many bone cells adhering if the periosteum is stripped from the bone. Thus, although the fibrous periosteum is in all probability a limiting membrane to protect surrounding tissues from invasion by bone cells (see Myositis Ossificans Traumatica, which follows its rupture), yet when it is stripped off, the bone cells adherent to the vessels from the canals lead to extensive new bone formation under the avulsed periosteum; this has led to this membrane being regarded as an actively bone-forming tissue, which in itself it is not.

The functions of the bony system are to supply a rigid frame for the body, at the same time giving attachments and mechanical purchase to muscles and tendons, and to afford a protection to soft and easily damaged tissues, such as the brain and viscera; it will be seen, therefore, that bones of necessity will differ much in shape, according to which of these two functions they fulfil. Thus the bones designed to protect will be of a flat shape and consist largely of compact bone, such are *flat bones*, as in the skull; whereas those designed for support will consist of columns varying in shape and size, according to the moulding and movements necessary in the various parts of the individual, and consisting of a core of soft tissue to lessen the weight as far as is compatible with the safe support afforded by a covering of compact bone; hence these are known as *long* and *short bones*, as instanced by the femur and vertebræ respectively. In order to allow of the bone growing to keep pace with the growth of the soft tissues, it is developed in a shaft or diaphysis and one or more terminal epiphyses, in which secondary bone centres develop; these are separated from the primary shaft centre by an area of cartilage which persists till growth is complete, *i.e.*, eighteen to twenty-five years, and is known as the Epiphyseal cartilage or **Epiphyseal Line.** This, of course, can be present only in those bones primarily developed from cartilage, *i.e.*, all the long bones, the ribs and base of the skull, whereas membrane bones, those of the skull vault, face, and a portion of the clavicle develop only from a primary centre, which shows as a series of radiating calcified spicules in the fibrous matrix, and usually appears considerably earlier in development than the corresponding ossific centres in the cartilage bones.

Inasmuch as infections of bone are nearly all blood-borne secondarily to disease elsewhere in the body, it is essential to gain a clear picture of the distribution of the blood vessels to a bone, and the first point to be grasped is that the vessels, both to the primary shaft centres and secondary epiphyseal ones, are practically end-arteries, as they are cut off by avascular cartilage from communication with one another, and only anastomose slightly with the periosteal vessels in the Haversian canals. Thus any bacteria gaining access to the bone are unable to escape as they get held up in the ultimate ramifications of the vessels at the extreme edge of the growing bone (the metaphysis in the case of the shaft); moreover, when inflammatory reaction sets in with exudation in the Haversian canals around the vessels, the pressure soon obliterates the vessels, and as they have no anastomosis death of the area of bone supplied beyond the area of thrombosis rapidly results in consequence of cessation of the blood supply, a condition analogous to that seen in " infarct " of the lungs or kidney and resulting in and showing the same wedge shape with its base to the periphery, due to the radiating distribution of the vessel. The blood supply to most bones is derived from three sources, the first two being constant to all bones, and the third confined to those with articular ends :—

(1) The *Nutrient artery*, which enters the nutrient foramen and breaks up into two main branches, passing through the medulla towards the ends, where each terminates in a capillary plexus at the metaphysis.

(2) The *Periosteal arteries*, which are numerous small vessels passing in through the periosteum, through small canals in the superficial lamellæ of the hard bone, and anastomosing with the branches of the nutrient arteries in the Haversian canals.

(3) The articular vessels unite around the reflexion of the synovial membrane on the bone surface to form a freely anastomosing circle around the bone at this point (*Circulus Vasculosus* of Hunter), and from this branches pass—

(*a*) To the ossific nucleus of the epiphysis.
(*b*) To the synovial membrane and intra-articular structures (if any) of the joint.
(*c*) To the periosteum and perichondrium of the bone and epiphysis.
(*d*) To the metaphysis—these being very few, and only anastomosing scantily with the nutrient vessels.
(*e*) To anastomose with the circulus vasculosus at the other extremity of the synovial membrane, *i.e.*, on the other bone forming the joint.

Growth, as in all tissues, will of course take place in length, girth and density, and is therefore present at all ossific centres and throughout the walls of the Haversian systems, being active especially on the shaft side of the epiphyseal line, the *metaphysis*, *i.e.*, the edge of what was the primary centre. Here large amounts of very vascular and imperfectly formed new bone exist, and here, therefore, infections are very likely to occur, for the vessels are end loops and capillary buds, in which organisms are liable to lodge among the immature bone and islets of avascular cartilage in this region.

Hyaline cartilage, in which many bones are laid down and which persists at the epiphyseal line of such bones and caps their articular extremities, is an avascular issue with a consequent bluish white, semitranslucent appearance, consisting of a number of groups of cells arranged in a homogeneous medium through which percolates the lymph on which the nutriment of the tissue depends. This cartilage, being avascular, is little liable to blood-borne infections, but should direct or contiguous infection occur, extensive necrosis will result by reason both of its lack of resistance from the absence of blood and consequent inability to react, and the fact that the disease of the surrounding tissue will cut off the lymph supply on which the vitality of the cartilage depends.

CONGENITAL ABSENCE OF BONES

As will be seen from the above, failure of development of any bone may occur, with absence and consequent deformity due to lack of support and abnormal muscle action. The radius, tibia and fibula (see pp. 690, 707) are most commonly deficient, but, occasionally, other bones may be absent or only partly developed; thus in a vertebra, if only one of the laterally placed body centres grows, a wedge-shaped vertebra, with Congenital Scoliosis (Vol. II., Chapter III.), results; failure of the laminal epiphyses to develop causes Spina Bifida (Vol. II., Chapter III.)

An interesting familial abnormality is seen in congenital absence of one or both clavicles (outer ends), so that the shoulders can be approximated across the chest, which is associated frequently with imperfect ossification of other membrane bones; thus the vault of the skull is soft and the fontanelles large and persistent, a condition known as **cleidocranial dysostosis.**

Occasionally premature disappearance of epiphyseal junctions leads to early cessation of growth, with shortening and deformity of a limb, or even of the whole individual, as occurs in **achondroplasia**; in the case of the mandible this synostosis may be serious, as the deformed underhung lower jaw will not permit of opening the mouth. The treatment in such a case consists in splitting the symphysis menti.

True **hypertrophy** occurs in gigantism, including acromegaly, and is the result of ill-balanced secretion of the ductless glands. Similarly, **atrophy** follows not only on prolonged disuse, but also from abnormal internal secretions, causing decalcification of the osseous tissue, when such diseases as fragilitas ossium and osteitis fibrosa result. (See p. 570.)

INFLAMMATION OF BONE

In the consideration of inflammation of bone two facts must be clearly understood:—

(1) That the various parts of the bone are one, the periosteum, osteum and medulla being intimately connected and continuous with one another; wherefore it follows that an inflammatory process in a bone will affect all these structures in a greater or lesser degree, and it is thus absurd to discuss the diseases of the three constituent parts separately. Hence the older terms, periostitis, osteitis and osteomyelitis, as denoting separate diseases, will be abandoned and the inflammations of bone tissue alluded to as **osteitis,** a term which can be regarded as covering all the essential structures of a bone. Osteoperiostitis is a term which can be kept in certain special cases.

(2) That the pathological phenomena of inflammation are primarily the same as in any other tissue, *i e.*, hyperæmia, exudation, leucocytosis, etc., and are, as in other parts of the body, called into being by an irritation, such as injury or infection; but that the rigid structure of the bone, in which these changes occur, prevents the tissues swelling and so modifies the phenomena, that secondary changes, which result from the pressure in the bony canals obliterating the vessels and irritating the nerves, cause rapid death of large areas of the infected bone, accompanied by agonising pain and severe toxæmia, with, as has already been explained (p. 528), a marked tendency to blood-stream infection and pyæmia.

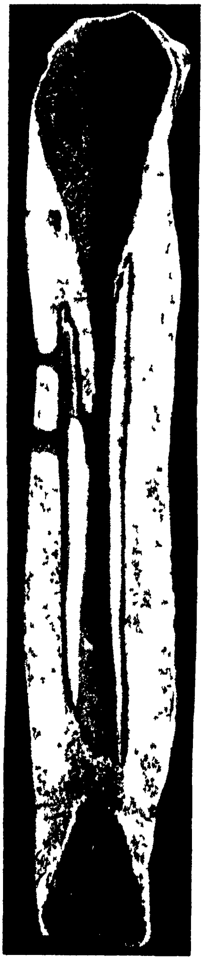


FIG. 251. Central osteitis of the tibia, with sequestrum formation and surrounding septic osteoperiostitis, showing two cloacæ.

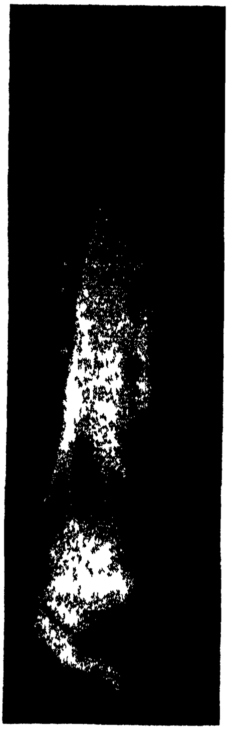


FIG. 252. X-ray film of a somewhat similar case to Fig. 251.

Gangrene in the case of bone is known as *necrosis*, and for the reasons stated, together with the fact that the nutrient vessel is to all intents and purposes an end-artery, is of considerable extent and occurs early in acute inflammation of bone, of which it is a frequent sequel.

In less acute cases, where the destruction by the toxins and absorption of this dead bone around the Haversian canals by the tissue cells keep pace with or even exceed the exudation and inflammatory reaction called forth by the infection, necrosis is averted, but an osteoporosis results, this microscopic destruction of tissue being comparable to ulceration in soft tissues, a process spoken of as *caries* in the case of bone ; or, as both to naked-eye appearance and on X-ray examination the affected area is seen to be porous and less dense than normal, this process is sometimes called *rarefaction*. It is thus evident that owing to the density of its structure and the nature of its vascular supply, bone is particularly liable to serious complications as a result of inflammatory reaction to infection which in soft tissues would produce neither infective gangrene, *i.e.*, necrosis, nor septic ulceration, *i.e.*, caries ; as these two conditions are so very frequent in bone it is well to say a few words about them at this place.

Necrosis or death of bone in bulk rapidly follows acute infection ; the resulting dead mass (*sequestrum*), being separated from the periosteum, presents a smooth, dead-white appearance—rather like ivory. At first it is not possible to distinguish the limits of the dead mass, but in a few days a line of demarcation is formed, as in any gangrene, and separation by ulceration (caries) slowly takes place at both ends ; but owing to the dense nature of the tissue affected this process takes weeks or even months, according to the bulk of dead bone to be thrown off, when such a mass can be properly spoken of as a sequestrum (above). This term is, however, usually applied loosely to any visible area of dead bone, whether separated completely from the living tissue or not.

All the time the sequestrum is separating, granulation tissue thrown out from the under-surface of the vascular periosteum, which has been stripped away by the pus, gradually encroaches on the dead mass and causes partial absorption of its surface, which in consequence loses its smooth appearance and acquires a characteristic worm-eaten appearance, though still preserving its dead-white colour. In the meanwhile the bone cells (osteoblasts and osteoclasts), stripped from the canals with the periosteal vessels (p. 527), form a layer of new bone deep to the periosteum, which, as it is lying in an infected cavity, is both great in amount and assumes the typical coral-like appearance to be expected in a septic osteoperiostitis (p. 533). This layer ensheathing the sequestrum is known as the *Involucrum* and may be very thick, acquiring four or five times the girth of the dead bone, and sometimes exceeding

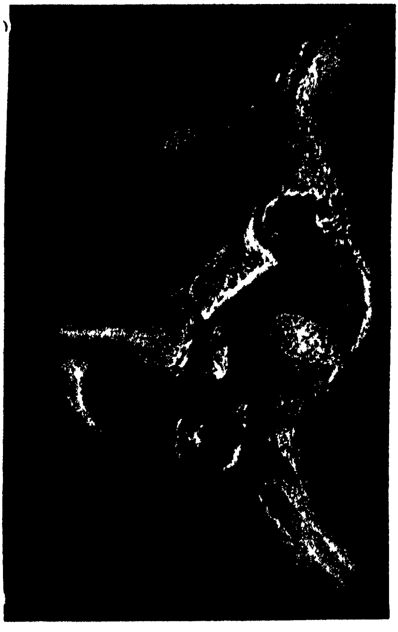


FIG. 253. Caries of the acetabulum and femur due to tuberculosis, with involvement of the hip.

it in length. It is, however, always perforated by numerous holes (*cloacæ*) communicating with granulating sinuses in the soft tissues, through which pus from the infected granulation tissue lining the involucrum and even spicules of dead bone from the contained sequestrum, can reach the surface.

Should the sequestrum, or any portion of it, come to lie in direct contact with the air, uncovered by granulations, then the surface in course of time becomes black over the exposed area due to the formation of calcium sulphide in the dead bone; this blackened appearance is seen most often in sequestra of the skull, where ulceration of the overlying scalp has supervened, but may be met with occasionally at the bottom of sinuses and ulcers of the leg.

To reiterate briefly, necrosis due to whatever cause results in the formation of a dead-white sequestrum, at first smooth in appearance, but later becoming pitted and worm-eaten on the surface, where it is in contact with the granulations on the inner surface of the involucrum; this is formed from the bone cells stripped up with the periosteum and perforated by numerous cloacæ to allow the escape of pus from the cavity.

Caries results when bone destruction rather exceeds or keeps pace with exudation and new bone formation, being a process analogous to ulceration in soft tissues, and is seen typically in tuberculous infection of bone. Owing to the thinning of the bone plates and enlargement of the canals the bone is porous, light and friable, and the condition is sometimes spoken of as *osteoporosis* or *rarefaction*. The Haversian canals are filled with granulation tissue which is invading and absorbing the surrounding bone, on the surface of which occur shallow pits (Howslip's lacunæ), in which lie osteoblasts among the granulations; hence at the edges of the bone small quantities of feathery new bone are thrown out. Thus on X-ray examination, the bone being thinned and so deficient of calcium salts, a poor and indefinite or "rarefied" shadow is thrown on the film, a condition typical of caries and atrophy.

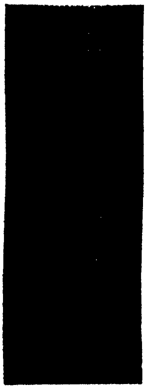


FIG. 254. Dense new bone and obliteration of the medullary canal of the tibia in gummatous osteoperiostitis.

Three varieties of caries are usually described:—

(1) **Caries suppurativa,** where the ulcerative process is accompanied by liquefaction and suppuration.

(2) **Caries necrotica,** a contradictory term, used to describe a common condition where the toxins cause death of pieces of cancellous bone, which constitute powdery friable sequestra varying in size from minute spicules to rounded marble-sized masses. The condition usually occurs associated with caries suppurativa, especially if a secondary pyogenic infection has been superadded to an original tuberculous caries.

(3) **Caries Sicca.** Dry caries, where no pus formation occurs, is rarely seen except in tuberculous infection of the upper end of the humerus in adults (q.v., p. 660). Occasionally it occurs in the head of the femur.

It must be remembered that caries may result from a variety of causes, though most often seen in tuberculosis of bone, so that a diagnosis of caries necessitates the addition of its ætiological disease to be complete.

The Process of Repair. As in inflammation elsewhere, so in bone, any inflammatory process results in repair and scar formation around and subsequently in the affected area; but whereas in soft tissues this scar is of more or less vascularised fibrous tissue, in the case of bones (other than the membrane bones of the skull vault) the process goes a step farther and new bone is laid down around and not infrequently in the area affected.

In the new bone laid down after trauma, *i.e.*, under aseptic conditions, the Haversian systems are reformed and the bone structure ultimately re-established, after the formation of a rapidly disappearing mass of ossifying fibrous tissue (*callus*) in the region of the damage (Chapter XIV., p. 412). Where infection of any nature is present, however, the process of repair is modified and the bone structure is seldom re-formed properly, this being due partly to the fact that the new bone is formed in the presence of infective agents and partly to its being mainly subperiosteal in origin. This process of new bone formation can be alluded to very properly as an **Osteoperiostitis**, for it is mainly under the periosteum that this new bone is laid down, as is well seen in the involucrum formed around the sequestrum after acute osteitis (Fig. 251), and it is certainly most manifest at the bone periphery in contrast to the surrounding soft parts, although the processes of repair are, of course, in progress throughout the whole bone.

The amount and density of the new bone laid down varies very considerably in different diseases, being very dense and compact in syphilis (*osteosclerosis*), profuse but porous in septic infection, and small in amount and feathery in tuberculosis; while in osteogenic sarcomata the new bone is usually laid down in regular spicules radiating from and at right angles to the bone shaft under the raised periosteum

It must be clearly realised that it is the results of the process of repair, the scar tissue consequent upon the inflammatory reaction called forth in the bone by irritation, that constitute the main bulk of the bone specimens seen in pathological museums.

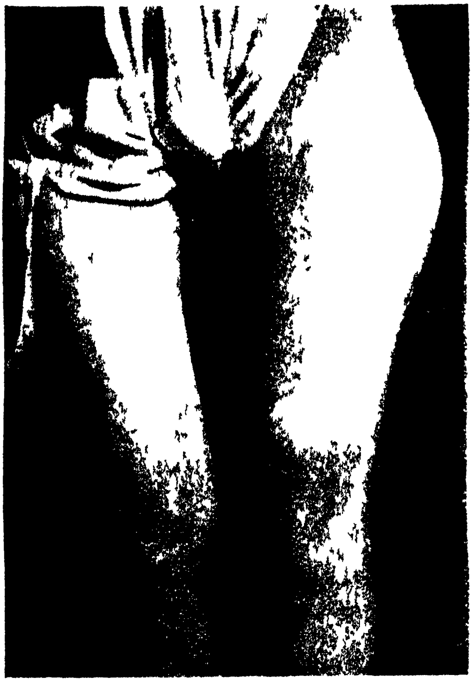


FIG. 255. Malunited fracture of the shaft of the femur, with angular deformity and "callus" (aseptic osteoperiostitis).

INJURIES TO BONES

Injuries, if slight, lead to contusion of bone and periosteum, with subsequent organisation of blood clot and new bone formation, which are manifested clinically as ovoid nodules (*subperiosteal nodes*), continuous at their margins with the surrounding bone, and usually met with on subcutaneous bones, such as the tibia and ulna; if severe, fractures, separation of epiphyses or dislocations result, with subsequent repair by callus and new bone formation. All these conditions and the necessity for prompt and accurate reduction of the deformity caused by the direction of the fracturing force, the pull of the attached muscles on the bone fragments, and the action of gravity, together with the consideration of the most adequate methods of splintage to retain the replaced fragments in position, and the best way of maintaining the nutrition of the soft tissue by various physiotherapeutic means while at the same time maintaining the alignment of the broken bone, have been dealt with fully in Chapter XIV.; they need no further comment than a passing reminder that the trauma is an irritant and the process of repair the natural inflammatory reaction of the tissues.

INFECTION OF BONE

Infection of bone is due to invasion of this tissue by micro-organisms and calls forth in response an inflammatory reaction (*osteitis*), which may be either acute or chronic in its ætiology and clinical manifestations.

Acute osteitis is almost invariably the result of infection by the Staphylococcus aureus; other organisms, Staphylococcus albus, streptococcus, pneumococcus, B. typhosus, and very rarely B. coli, are occasionally met with as causes of this condition, and inasmuch as all are pyogenic, pus formation is usually an early and constant sequel to acute infection of bone.

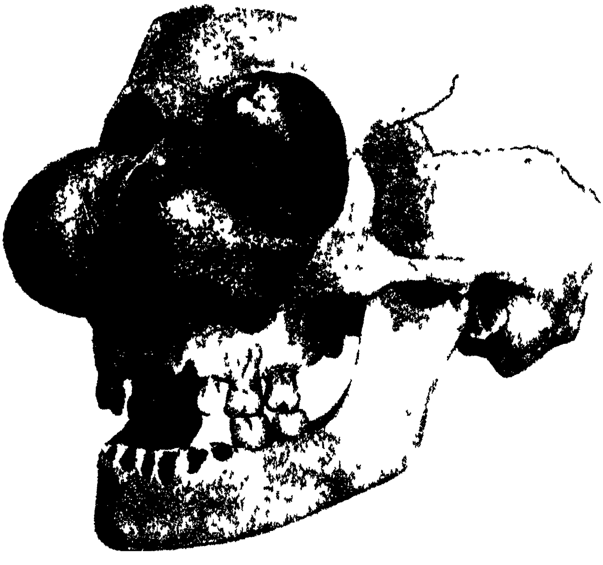


FIG. 256. Skull showing septic osteoperiostitis secondary to chronic infection of the air sinuses "Leontiasis Ossium."

Inasmuch as the infection is blood borne and must indeed be regarded as a localising focus in the course of a general septicæmia in nearly all cases, a blood culture is often positive, and the septicæmia may be so severe as to mask the local, and secondary, lesion in the bone.

Chronic osteitis may, as in other tissues, result from the effects of an acute pyogenic infection or be chronic from the first as a result of a milder irritation due to—

(1) Attenuated pyogenic organisms.

(2) Specific micro-organisms, such as B. tuberculosis, Treponema pallidum, etc.

(3) The presence of parasites, *i.e.*, hydatids.

(4) The presence of a neoplasm, such as sarcoma or secondary carcinoma, or more rarely a simple tumour.

(5) A compensatory hypertrophy, in attempting to maintain the strength and stability of the bones in certain diseases where decalcification takes place *i.e.*, rickets, osteomalacia, osteitis deformans, etc.

As has been already pointed out (pp. 532, 533), the new bone laid down under these varying conditions differs much in quantity, density and consistence, so that a shrewd idea of the nature of the infection can often be drawn from the appearance of the results of the reparative osteoperiostitis. As a general rule these bone infections occur from the blood stream in the course of a septicæmia, which in itself may be so severe as to mask and overshadow the signs of the bone infection; but it is usually not acute, and the bone condition is frequently the first indication of the presence of micro-organisms in the blood stream.

As might be inferred from the knowledge that the infection is usually blood-borne, the main stress of the local disease is primarily on the vascular medulla at the ends of long bones and is most commonly situated in the terminal capillary loops of the nutrient blood vessels which, as already pointed out (p. 528), are immediately on the shaft side of the epiphyseal line (*central osteitis*). This area, being formed of immature and actively growing tissue and avascular cartilage, is a particularly good pabulum for bacterial growth, and being, moreover, both from its situation near joints and its instability, particularly liable and susceptible to trauma, it is further prone to fall an easy prey to infecting organisms. Hence we find that osteitis is far commoner in the long and short bones of the limbs than in the more compact and protected short, flat bones of the trunk, and that it is a disease of childhood and early adolescence, when the metaphyseal conditions are more suitable for bacterial infection and growth. It should be realised, however, that infection *via* the branches of the circulus vasculosus of Hunter, formed by the articular vessels around the reflexion of the joint synovial membrane, may occur either in the epiphyseal nucleus, when an *epiphysitis* results, a condition usually met with in very young children (Fig. 260), or through the periosteal vessels, when the infection is usually limited to a plaque-like superficial area of the compact bone (*peripheral osteitis*), but may spread into the medulla and give rise to a generalised osteitis, which in this case may result in any part of the affected bone. Sometimes direct infection of bone occurs either from a wound involving both the bone and soft parts, as is seen in an amputation, a compound fracture, or from extensive laceration of surrounding soft tissues, with contused bone among them which becomes infected; in this case the condition, if acute, is sometimes alluded to as *septic osteitis*, but in no way differs from the osteitis called forth by an infection reaching the bone by the blood stream, except that it tends to be much less severe.

The results of the infection, as already pointed out, are to cause an inflammatory osteitis which, as in other tissues, may result in :—

1. *Resolution*, in which case the condition settles down, and beyond a transient period of pain and tenderness in the end of the affected bone, and possibly a slight effusion into the joint for a day or so, no ill effects remain. The condition may recur, and is one of the common causes of "growing pains" in childhood.

2. *Localisation.* (*a*) *Without pus formation*, in which case there is primarily a condition of caries (p. 532) and pain in the affected area, with often a serous effusion in the neighbouring joint; repair sets in early and the bone structure

usually is restored, with frequently some increase in density of the bone lamellæ, which may be so marked as to cause osteosclerosis (p. 539); in this case considerable osteoperiostitis usually occurs, resulting in a fusiform thickening of the affected area.

(*b*) *With formation of a localised abscess.* In this case more or less osteosclerosis occurs around the pus-containing cavity and frequently osteoperiostitis leads to thickening of the bone and effusion into the neighbouring joint. The condition is known as **Brodie's Abscess** and may occur as the result of septic, tuberculous or syphilitic infection being localised in the cancellous tissue of the metaphysis of a long bone, usually the tibia or femur; the great majority of cases are septic. Such a bone abscess is liable to exacerbations of pain and tenderness, consequent on spread of the infection from the cavity, following slight trauma, etc. (p. 541).

3. *Generalised infection of the whole bone* may result from failure of a partly-formed abscess to localise or from general spread of the infection throughout the medulla and Haversian canals of the bone, a condition comparable to cellulitis in the soft parts. In the former case the resulting osteitis probably will be localised to the infected end of the bone and the clinical signs be less severe and generalised than in the latter, where the entire bone is affected and the patient's life threatened by the virulence of the toxæmia. In either case, as already pointed out, necrosis (p. 531) of the whole area involved usually occurs early, with subsequent sequestrum formation and a resultant chronic osteoperiostitis of a septic nature.

In the acute stages, under these conditions, the pus under tension will cause severe pain and toxæmia; it will seek an outlet of escape along the line of least resistance, this being usually along the shaft side of the epiphyseal line to beneath the periosteum; but sometimes the abscess will point into the medullary cavity or penetrate the epiphyseal line into the epiphysis. In this connection two things must be remembered clearly: firstly, that the periosteum is firmly attached at the epiphyseal line, and that, therefore, separation of the epiphysis may occur from the diaphysis; so that the pus, after its escape under the periosteum, will travel up and around the shaft of the bone, stripping the periosteum from this and thus depriving the underlying superficial bone of its main blood supply at the same time as it infects it with bacteria; and secondly, that the pus will escape ultimately through the periosteum into the surrounding tissues, so that if, as is often the case, the epiphyseal line is situated within the joint cavity, or in all cases when the pus escapes through the epiphysis, secondary involvement of the joint is inevitable; thus *septic arthritis* is a common and very serious complication of acute osteitis.

In *cartilage* inflammation nearly always results in massive death (necrosis), the tissue being avascular; indeed, infection of the underlying bone not infrequently causes gangrene and exfoliation of the cartilage attached to it by cutting off its lymph supply, though this hyaline cartilage may have escaped actual infection owing to its avascularity, which has, however, directly caused it to necrose. It thus follows that severe osteitis may be followed by death of the epiphyseal cartilage and subsequent non-growth in length of the affected bone with dwarfing of the limb, a condition, however, not so frequently seen as partial destruction with subsequent irregular growth and deformity of the limb, or irritation with consequent overgrowth in length of the affected bone.

It will be understood from the foregoing brief descriptions that in bone the processes of infection and consequent inflammation, and its resultant attempts at repair, differ in no way in their essentials from similar conditions in other tissues, but that the rigid structure of the bone and its tendency to new formation as a result of inflammatory reaction so modify these reactions that at first sight they appear not to conform with those seen elsewhere in the body.

PYOGENIC INFECTION OF BONE

Acute infection of bone (acute osteitis) is due almost invariably to the Staphylococcus aureus or albus, or rarely the streptococcus, pneumococcus or B. typhosus, which usually reach the bone by the blood stream, whence they have come from some septic focus elsewhere in the body, such as a cutaneous furuncle, chronic otitis media, tonsillitis, impetigo, septic grazes, or not infrequently during the course of an acute exanthema. It follows that the bone disease must be regarded as a localising manifestation in the course of a septicæmia, and as such is of fair prognosis and should be interfered with as little as possible; at the same time, owing to the particular structure of bone (already referred to, p. 535), prompt relief of tension is necessary to save the life of the bone and ease the severe pain resulting from the tension in its rigid structure. The disease is seen most commonly in debilitated young children or adolescents of the working class, occurring only very occasionally in adults, and is notably both rarer and less virulent in recent years, due to more efficient hygiene among the poor classes, apart from whom the condition is almost unknown.

The infection, being blood-borne, usually enters by the nutrient vessel and the organisms become held up in the capillary loops of the metaphysis, and here find an admirable nidus among the delicate new bone and avascular cartilage on the diaphyseal side of the epiphyseal line; occasionally the organisms may enter by the epiphyseal vessels and attack the secondary ossific centre, when an **acute epiphysitis** results, the joint being then very prone to infection; or the compact bone may be infected through one or more periosteal vessels, when the inflammation is limited to a superficial area and a plaque-like sequestrum usually results, giving this condition its name of **exfoliative osteitis.**

Clinically the child, usually below the age of puberty, who has often just recovered from measles or has a history of recent injury to the part, is obviously ill—there being lassitude, a flushed face, and a bright eye—and usually screams at any attempt at examination or movement of the affected limb, mainly from apprehension of the extreme pain which experience has taught results from such manipulations; but in very severe cases of the generalised type, toxæmia may render the child comatose, a sign of grave significance, as such cases are always fatal. The temperature is usually high, 103° to 105° F., but may be subnormal in very severe cases; there may be rigors, in which case pyæmic abscesses or septic broncho-pneumonia usually develop later or are found post-mortem, the pulse is weak and rapid, the skin dry, the tongue furred, constipation marked and obstinate, and the urine high-coloured and scanty.

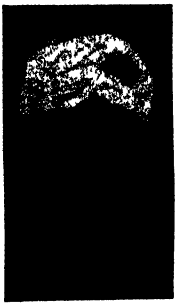


FIG. 257. Epiphysitis of humerus.

The disease tends to be more severe in the small bones than in bigger ones, *i.e.*, in the clavicle or the crest of the ilium it is both rare and very severe.

There is swelling and usually mottled reddish discoloration over the affected area, which is commonly at the extremity of one of the long bones, frequently at the knee or ankle, but it must be remembered that flat bones, *i.e.*, the skull or pelvis, and short bones, as the clavicle or vertebræ, may be affected, when similar signs will be observed in the soft parts covering them. The part is acutely tender to the touch, but apart from this the patient is obviously in great pain. Œdema can be detected early, while fluctuation is present in the later stages, when pus has escaped under or around the periosteum, a phenomenon also accompanied by considerable decrease in pain due to easing of the tension in the bone. Effusion can be demonstrated nearly always in the neighbouring joint in the case of infection at the ends of long bones. This is at first serous, but if the pus has penetrated the joint (see p. 593) it rapidly becomes purulent and teeming with organisms, a serious condition of septic arthritis resulting, which, besides forming a large additional septic focus from which toxins are easily absorbed, causes serious deformity later from contraction following disorganisation of the joint (Chapter XIX., p. 594); in some cases a pathological dislocation rapidly occurs (Chapter XIX., p. 594). As already pointed out, separation and displacement of the epiphysis may be observed in some cases.

The diagnosis is at times very difficult, especially when toxæmia is very marked.

Occasionally more than one bone may be affected at the same time, and still more rarely both ends of the same bone will be involved simultaneously. Secondary pyæmic infection in other bones, with formation of painless abscesses which often escape notice for a time, is by no means uncommon after a week or so.

Inasmuch as septicæmia is present, a blood culture should be taken in all cases, and is positive in about 80 per cent., for which reason local evacuation of pus is at times not followed by any dramatic amelioration of the general signs or fall of temperature.

Treatment consists in prompt incision under general anæsthesia; this must be planned to be at the most dependent point as the patient lies in bed, and extend down to the periosteum in the affected area, care being taken to cut down on the bone shaft and avoid opening the joint or damaging the epiphysis. The periosteum must be exposed freely, and will be found red and congested; it should be incised, when usually pus will flow out; this shows that the pus is escaping freely from the interior of the bone and is an indication that no further treatment is indicated immediately; should, however, no pus flow through the periosteal incision, then the medullary cavity must be laid open with a gouge or trephine and the pus evacuated, though often none is met with even in the medulla; such an opening should be made in the diaphysis as near the epiphyseal line as is compatible with the integrity of that structure. We do not advocate the free opening of the whole medullary cavity and removal of masses of bone which may be living or dead (diaphysectomy), at this stage, as the more conservative measures usually amply suffice to allay the toxæmia and arrest necrosis, and it is only in those few cases in which periosteal incision or a small opening into the medulla fail to allay the toxæmia that the more drastic operation is permissible; for this not only gives no better results, but frequently causes spread of infection into healthy bone with increased necrosis and toxæmia, and, moreover, is a potent source of pathological fracture (p. 570). The mortality following incision and drainage is about 12 per cent., as against 20 per cent. where more drastic treatments are carried out locally. After operation the wound should be packed with gauze soaked in sterile paraffin and immobilised (if necessary by means of plaster of Paris splints). This dressing is left in situ for about three weeks and then changed, as it becomes very foul; if the area becomes painful or the temperature rises, the dressing must be renewed earlier. This dressing is repeated till the wound has healed and is painless. It is a great advance, and gives shorter convalescence than regular dressing with sterile gauze, suspension on pillows and immersion frequently in warm antiseptic baths. Should the joint be infected it must be drained from the most dependent part, as recommended in Chapter XIX., p. 594. Occasionally amputation may have to be resorted to to save the patient's life. General treatment for the septicæmia, warmth, fluids and a light but nutritious diet must be inaugurated, but inasmuch as the disease is most usually staphylococcal in origin sulphanilamide is not likely to help. Lately there has been a tendency to adopt more conservative local treatment with rest and fixation alone; this is certainly advisable in the case of inaccessible bones such as the bodies of the vertebræ. As the infection is usually staphylococcal, certain new specific anti-staphylococcal chemicals may be tried, such as euleron or M. & B. 750.

Subsequently the separation of the sequestrum should be checked by weekly X-ray examinations, and so soon as it appears to have separated it must be removed by a free incision through the involucrum. It is well to remember that separation of the sequestrum usually occurs before it is shown to be complete in an X-ray film, the average time being two to three months for a large sequestrum in a long bone such as the femur or humerus, and that the sequestrum is usually considerably longer than shown by an X-ray picture, the thin ends being concealed by the involucrum.

To obtain success it is essential to operate before the new bone of the involucrum is so rigid that it will not collapse and mould as a result of muscle action, and so obliterate the cavity, from which the sequestrum, of course, must be completely removed, or else a sinus will persist. It must be realised that in early cases splintage may be necessary to maintain the shape of the limb, as the involucrum may not be rigid enough to do so per se. In old-standing cases, where a rigid involucrum around a cavity lined with chronically infected and purulent granulations keeps up a persistent sinus, even though the sequestrum has been removed, amyloid disease (Chapter VI., p. 267) is very liable to develop unless the cavity is obliterated; this can be done best by curetting away granulations and either chiselling away enough bone to permit the soft parts to fall in and obliterate the space, or if this is incompatible with the stability of the limb, packing with gauze soaked in paraffin, as described above, or by introducing a muscle graft and putting the part at rest for three weeks, when the graft may take successfully.

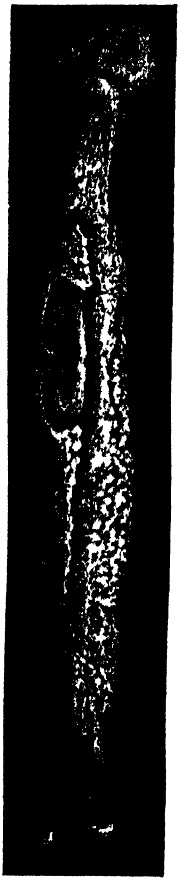


FIG. 258. Chronic septic osteoperiostitis of the tibia with a sequestrum following acute peripheral osteitis (exfoliative). Note the black discoloration of the sequestrum which has lain exposed to the air.

In cases of *exfoliative osteitis*, which usually occur following a local injury, the evacuation of the pus from the subperiosteal abscess usually suffices to allay all symptoms, the small sequestrum either disintegrating and absorbing or being subsequently separated naturally and extruded through the sinus.

The *prognosis*, as in all cases where a septicæmia exists, is always grave, severe toxæmia and coma being of serious import, while the risk of local complications, such as joint infection (suppurative arthritis), pathological dislocation, fracture or separation of epiphysis, and the more serious general complications of pyæmia, purulent bronchopneumonia, empyema, purulent pericarditis, and cerebral abscess, etc., is very great and of serious significance. In old-standing cases, with persistent sinuses, amyloid disease or squamous carcinoma not infrequently supervene, and mean at least sacrifice of the affected part, if not subsequent loss of life.

In the skull the prognosis is bad, as extradural abscess or meningitis is apt to supervene; similarly in the vertebræ, mediastinitis, empyema, and pyopericardium in the thoracic portion, peritonitis in the lumbar, and to a lesser extent retropharyngeal abscess in the cervical regions, are all serious and often fatal complications.

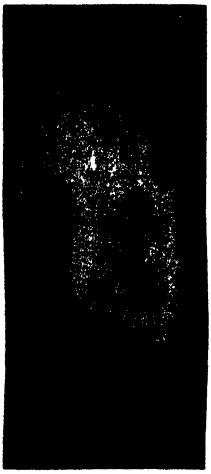


FIG. 259. Chronic osteoperiostitis of the humerus with sequestra in situ, secondary to septic osteitis.

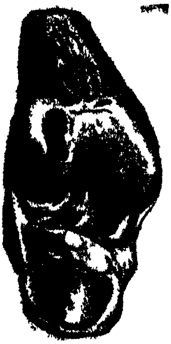


FIG. 260. Abscess in the lower femoral epiphysis (epiphysitis) which has burst into the knee-joint, causing acute synovitis.

Differential diagnosis may present some difficulty, one of the most frequent causes of error being *erythema nodosum*, which, however, usually occurs on both legs of young women who are not generally ill, the local condition being present over the centre of the bone as well as at the ends and not being nearly so acutely tender as the swelling in osteitis. *Acute arthritis* due to causes other than osteitis, to which it is so frequently secondary (50 per cent. of cases), may cause difficulty in diagnosis; local wounds should be sought for and the question of gonococcal and rheumatic infections carefully excluded. *Periosteal sarcoma* and *cellulitis* in the soft parts around the bone may cause great trouble in diagnosis. An X-ray film will be very helpful, but usually careful clinical examination, noting, in the case of cellulitis, that active but not passive movements cause pain, will clear up the diagnosis.

In severe toxic cases the condition may be mistaken for the onset of an acute illness, such as meningitis, typhoid fever, pneumonia or scarlet fever, the septicæmia masking and overshadowing the local lesion, which is only discovered at the autopsy.

Acute Epiphysitis is a disease met with in young children and is almost invariably fatal, the causative organism being often a streptococcus. As already explained, the pathology of the condition in no way differs from that of acute osteitis, save that the ossific nucleus of the epiphysis is the seat of infection, which reaches it by the blood vessels to the epiphysis derived from the circulus vasculosus, described by Hunter; this is an anastomosis of articular vessels around the point of reflexion of the synovial membrane on the bone, from which branches pass to the synovial membrane, intra-articular structures, epiphysis and periosteum, and a few branches to the metaphysis. It follows that the pus bursts rapidly into the joint cavity, and so septic arthritis supervenes inevitably and early, and is, indeed, often present when the case is seen first (Fig. 260)

Clinically the signs are the same as those seen in acute osteitis, but the joint is always swollen, full of fluid, and acutely tender, and the baby very ill indeed and usually semiconscious.

Treatment consists in opening and draining the joint (see p. 594), but amputation is often necessary because of the toxæmia, which may be combated with sulphanilamides in streptococcal cases.

The *prognosis* is very grave, the disease being nearly always fatal.

The *diagnosis* from acute rheumatism may be made by the facts that this is rare in children under one year of age, and then not usually confined to one joint, and that aspiration yields a purulent fluid in epiphysitis.

Subacute Epiphysitis, either septic or syphilitic, is by no means rare, and the condition very closely resembles that of acute epiphysitis; but the child is usually well enough to realise it is in pain and cries lustily. Separation of the epiphysis is not uncommon in this condition.

Chronic Osteitis due to pyogenic infection is by no means uncommon and is usually met with either as a result of an acute lesion which has been localised by tissue reaction, when a Brodie's abscess is usually present in the centre of the area, or as the result of the laying down of new bone in a chronically infected cavity as a sequel to acute osteomyelitis, where the new bone (involucrum) forms the support of the part and becomes moulded by muscle action and pressure into approximately the shape of the dead bone it replaces; the new bone, however, never reforms regular Haversian systems, being mainly derived from subperiosteal bone cells, and has a typical roughened and porous appearance suggestive of coral.

FIG. 261. Chronic septic osteoperiostitis of the humerus with cloacæ, following acute osteitis.

Localised Abscess of Bone—"Brodie's Abscess"—was first described about 1845 by Sir Benjamin Brodie as being due to chronic septic infection of bone, and is, indeed, generally so caused; it also occasionally results from tuberculosis or the breaking down of a localised syphilitic gumma in the bone. In the majority of cases, however, the condition would appear to be pyogenic in origin, and not infrequently staphylococcus aureus or albus can be cultivated from the contained pus, although in old-standing abscesses the contained serous fluid is often sterile. The surrounding bone is generally thickened and dense, a condition seldom seen in tubercle, and there is often a history and signs of acute osteitis elsewhere in the body at a previous date; sometimes these abscesses flare up and cause an acute osteitis, though usually they only gradually develop and, at most, point locally, often following some local trauma. The condition is usually met with in young adults, the centre of the ends of the diaphysis of long bones being affected, particularly those of the tibia and lower end of the femur. Occasionally such an abscess may occur in the centre of the shaft of a long bone, the humerus being particularly liable to it, or rarely more than one bone abscess may be present.

The abscess cavity, usually about the size of a chestnut, often contains a thin greenish sero-pus, from which staphylococci may be grown, and is lined with a thin film of granulation tissue; but in old-standing cases the contents are serous and the granulation tissue in the wall becomes fibrous. Small bony sequestra may be found in the cavity, and the bone immediately around the abscess is always densely sclerosed in these septic cases, a condition which can be demonstrated by X-ray films; further out sclerosis is also present, often with obliteration of the medullary canal, which is replaced by a mass of new bone, but the Haversian systems persist There is, moreover, a considerable deposit of subperiosteal new bone.

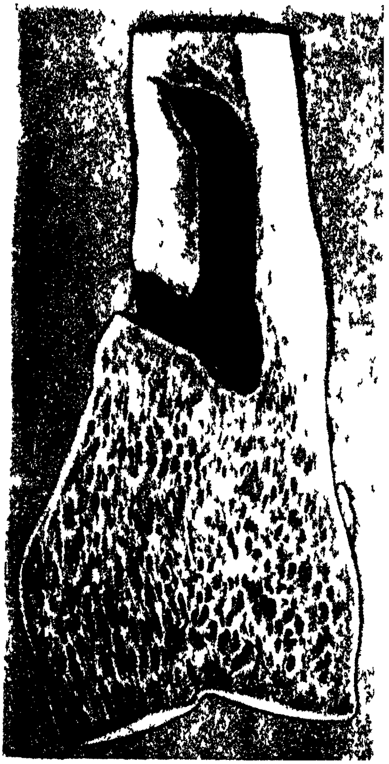


FIG. 262. Brodie's abscess of the lower end of femur, with sinus. "Chronic localised osteitis."

If left alone the fluid may absorb and the cavity become obliterated, when the so-called "quiet necrosis" of Paget results, but more often the abscess increases in size and ultimately points either along the epiphyseal line or through the epiphysis into the joint.

Clinically the adolescent usually complains of aching pain in the end of a bone, especially after use, with swelling of the neighbouring joint. On examination the part is usually swollen, and may appear reddened, and the muscles of the limb are often slightly wasted and always soft and flabby from loss of tone. Œdema of the soft parts may be present, with thickening of the synovial membrane, and perhaps fluid in the neighbouring joint.

Local tenderness, usually localised to one small spot, can be elicited on pressure, or better, by percussion over the affected area of the bone, which can be easily felt to present a hard fusiform thickening under the examining fingers. The part is usually rested in an elevated position and kept outside the bedclothes at night in order to avoid congestion and consequent pain ; for the same reason it is little used, and limping is often present if a lower extremity bone is affected. Should the abscess have burst out from the bone, acute septic arthritis or a subperiosteal abscess in the soft tissues may be detected.

Treatment. So soon as the condition is confirmed by an X-ray picture immediate operation should be undertaken, and in those cases where no X-ray examination is possible it is far safer to explore the bone than to risk the abscess bursting into the joint. The soft tissues are incised down to the bone, which is gouged away till the cavity of the abscess is freely laid open ; it is curetted out, and swabbed with strong peroxide or pure carbolic ; the wound is then closed and usually heals by first intention. Should, however, a sinus persist, as is not infrequent in tuberculous cases, more bone must be removed so as to let the muscles fill in and obliterate the cavity, or this may be packed with gauze soaked in sterile paraffin and left to granulate (see p. 539). Treatment on these lines is also imperative in Brodie's abscesses of tuberculous or syphilitic origin, as at the very worst a persistent sinus in the soft parts is better than an infected and disorganised joint ; in these cases general treatment of a suitable nature will be given, of course.

Diagnosis. A chronic abscess having been diagnosed, it is of importance to ascertain whether it is pyogenic, tuberculous, typhoid, or syphilitic in origin, and apart from general considerations, the local X-ray appearance often forms a good guide—thus in a tuberculous abscess there is little or no surrounding sclerosis of the bone in the immediate neighbourhood, and that beyond is often rarefied, whereas in syphilis the abscess is situated in the midst of a densely sclerosed area of bone, which is often widely disseminated and shows no signs of Haversian canals ; while the pyogenic abscess steers a happy mean between these two extremes, there being, as already described, some sclerosis, more marked around the cavity, but the Haversian systems remain intact. The differential diagnosis is by no means easy unless an X-ray film is available as the condition may closely resemble a *periosteal* or *central bone sarcoma*, or a *myeloma,* and indeed, it is only in those cases where previous evidence of acute osteitis can be obtained that anything like a definite diagnosis can be made in the absence of a good radiogram.

Another source of error, as can be seen from a study of the physical signs, is *tuberculous arthritis,* of which condition Brodie's abscess may be a precursor (see Chapter XIX., p. 598), but here the thickening of the end of the bone in pyogenic cases serves as a useful guide.

Typhoid Osteitis occurs as a sequel of typhoid fever, often not till years after the acute disease ; it usually occurs as a subperiosteal abscess about the ninth week of the disease. The tibia and ribs are most often affected, and not infrequently the bacillus invades the costal cartilages. The abscess is filled with a yellowish brown sero-pus, from which a pure culture of B. typhosus can be obtained; the Widal reaction is, of course, positive and the temperature remains raised. Necrosis of bone or cartilage but rarely occurs.

The local clinical signs are those of a deep-seated abscess, which can be demonstrated to be fixed to the underlying bone, though pain often may be complained of before this can be detected.

Treatment consists, if possible, in excising the affected portion of bone or cartilage and the contained abscess intact, as incision and curettage or drainage are frequently followed by the formation of a persistent or slowly healing sinus, which, of course, discharges B. typhosus.

It must be understood clearly that the discharge in all these cases is highly infectious; we have known one serious outbreak of typhoid in a hospital ward from an undetected case of chronic typhoid osteitis with a sinus of eighteen years' standing.

Septic Osteitis is the name given to pyogenic infections of bone which are not blood-borne, but result from direct infection of the bone in septic wounds and compound fractures. The pathology of the condition differs in no essential from that of acute blood-borne osteitis, except that there being a wound present and the bone being broken, the pus can escape earlier, and so neither the intensity of toxæmia nor extent of necrosis is so marked, though of course the latter varies directly with the amount of bone damaged. Should the infection occur in an amputation stump or around a septic compound fracture, then the typical tubular tapering sequestrum of septic osteitis is seen, but in those cases where the bone is comminuted, irregular and extensive sequestra will result, as the organisms can readily destroy the already damaged fragments. Should joint infection or gas gangrene complicate the condition, amputation is urgently called for to save the patient's life, otherwise the treatment consists in allowing free exit to pus and removing sequestra later.

FIG. 263. Sequestrum from a septic amputation stump showing pitting of the surface due to action of granulation tissue on the dead bone.

Regenerative Osteoperiostitis, as already mentioned, occurs subsequently to all inflammation in bone, and under aseptic conditions as seen in fractures reforms the original structure (Chapter XIV., p. 412).

Where pyogenic infection is present, however, and the only surviving bone cells are attached to the inner surface of the periosteum, the task of remaking the bone and so maintaining the rigidity of the part falls on these, and, as might be expected, the original structure is not reproduced, a solid mass of new bone resulting with but little medulla; moreover, the new bone has to be formed in the presence of organisms and granulation tissue which are for ever aiming at its destruction, and so the resulting mass is pitted and hollowed and presents a porous appearance much resembling a mass of coral. This coral-like appearance is typical of the new bone laid down in chronic osteoperiostitis and is, therefore, seen in all bone formed after pyogenic infections, *i.e.*, after acute osteitis, septic osteitis, Brodie's abscess, etc., and also in old-standing cases of bone tubercle wher secondary infection has occurred in the sinuses; here, indeed, the pyogenic osteoperiostitis may overshadow the results of the original infection completely, as is so often seen in museum specimens. As will be pointed out subsequently, the new bone laid down after tuberculosis is slight and feathery, whereas in syphilis it is usually large in amount and ivory-like in its appearance and density.

Chronic Epiphysitis, due to invasion of the ossific nucleus by pyogenic organisms, is occasionally seen and usually results in irregular growth, which, in the case of the epiphyses of long bones, leads to deformities, such as genu valgum, genu varum, talipes, cubitus varus and valgus, etc.

Schlatter's Disease was originally described as being a tuberculous infection of the anterior tubercle of the tibia, and this is occasionally the cause of the tender swollen condition of the upper part of the anterior tibial tubercle so frequently met with in boys about the age of puberty. The condition is, however, most often traumatic in origin, the upper (epiphyseal) portion of the tubercle being partly separated from the underlying shaft by the pull of the quadriceps extensor cruris through the ligamentum patellæ; hence it is often first noticed after a sudden strong kick at football or strenuous training for sports. Inflammatory reaction follows with osteoperiostitis, and the tubercle can be felt to be thickened and tender, besides giving pain if the limb be used; under normal circumstances the condition will settle down in three or four months, leaving a permanently enlarged tubercle, but during this period there is considerable disability and limping, and there is a danger of either septic or tuberculous infection supervening (see p. 547). In many respects this disease resembles Perthes' disease or Köhler's disease (q.v.).

Treatment consists in strapping the region and knee tightly with strips of zinc oxide plaster, the limb being in an extended position; the boy can then walk without pain. Scott's dressing may be put beneath the plaster, but this is unnecessary, rest being the essential. The plaster should be renewed at the end of ten days, and needs to be worn for three weeks or a month, when a cure is usually effected. Should the pain continue after strapping, or X-rays reveal tuberculous caries, plaster of Paris should be used to immobilise the region and knee joint and must be worn for three months after all pain has ceased.

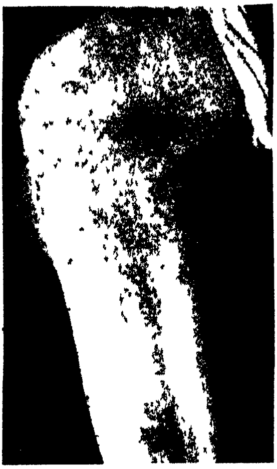


FIG. 264. Schlatter's disease.

Perthes' Disease (Pseudocoxalgia) is a deformed condition of the epiphysis of the head of the femur met with in young children of three to eight years of age, more often boys, and closely simulating in its physical signs tuberculosis of the hip joint (Chapter XX., p. 630). Uncertainty exists as to the ætiology of the condition; it is, however, traumatic epiphysitis due to interference with the blood supply of the epiphysis causing interference with and deformity of the epiphyseal centre, although some authorities regard the condition as infective in origin; it is significant that if left untreated the condition occasionally passes into active tuberculosis within two years of onset. It may follow the forcible reduction of a congenital dislocation of the hip.

Clinically the child is usually plump and well nourished, but complains of pain in the hip or knee on walking and is noticed to limp or to refuse to use the limb; the onset is usually insidious and may follow measles or some such disease. There may be a history of injury.

Examination shows the muscles of the affected limb to be poor of tone, flabby and wasted, and there is usually some spasm, the limb being held flexed, adducted and internally rotated; for the same reason all movements are limited, and if the condition has been long present compensatory lordosis and scoliosis, with tilting of the pelvis and apparent shortening of the affected limb, may be observed (Chapter XX., p. 623). The condition thus resembles a tuberculous hip, but a valuable clinical sign which will differentiate the condition can be elicited by asking the child to turn over, when it will do so on the affected or sound side indifferently, whereas a child with a tuberculous hip always turns on the sound side, except in old-standing cases where the joint is ankylosed.

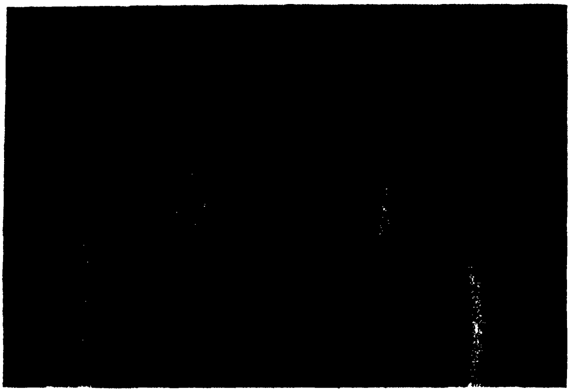


FIG. 265. Perthes' disease of the right hip joint.

X-ray examination also will differentiate the conditions, as in Perthes' disease the ossific centre of the femoral head presents the characteristic fragmented and flattened appearance, the bone being of increased density and the edges sharply defined, in contrast to the appearances seen in tuberculosis (Fig. 329, p. 631), where the centre is intact, but rarefied, and presents a blurred outline.

FIG. 266. Köhler's disease.

The prognosis is good if the condition is promptly and efficiently treated.

Treatment consists in applying traction in the acute stage, when the pain rapidly subsides; thereby excluding tuberculosis. The patient may then be got up with a walking caliper splint, which is worn until the X-ray film shows that the disease is healed. It is interesting to note that many of these cases do well even if no treatment is adopted (Chapter XIX., p. 604).

Kohler's Disease is a somewhat similar condition seen in the scaphoid bone of the tarsus in children of a slightly older age, three to seven years, and attributed to the same causes.

Clinically there is sometimes a sudden onset, but usually it is insidious, with pain and stiffness on the inner side of the foot, and occasional swelling and redness, so that pes planus and rheumatism may be suspected. An X-ray film shows the scaphoid to be much smaller and denser than normal, with a characteristic flattened shape ; occasionally fragmentation may be present.

Treatment consists in strapping up the instep or applying plaster of Paris for three months to fix the foot, but even with no treatment the condition usually settles in a few months, and the bone assumes a normal size and appearance, both on clinical and X-ray examination.

Kienboch's Disease is a similar condition affecting the os lunatum (semilunar) in the carpus. The wrist should be fixed in dorsiflexion, otherwise the same principles apply as in Köhler's disease.

Calvé's Disease is a similar condition affecting the centra of one or more vertebræ in infants and resulting in kyphosis or scoliosis.

TUBERCULOSIS OF BONE

Invasion of bone by B. tuberculosis is a blood-borne infection, secondary to tuberculous lesions elsewhere in the body, usually infected bronchial or mesenteric glands, and is a disease which may occur at any period of life; though most commonly seen in childhood or early adolescence, when the growing ossific nuclei are particularly liable to infection, it is not infrequently met with in old people (senile tuberculosis).

The disease, as elsewhere, is insidious in onset, and causes a local reaction, with formation of granulation tissue and some obliterative endarteritis; these result in microscopic death of tissue usually at such a rate that it can be removed as fast as it is destroyed, though occasionally small sequestra may be visible; frequently also in liquefaction of the disintegrated products of the action of the bacillary toxins and inflammatory reaction, with the formation of tuberculous pus (Chapter VI., p. 107). It thus follows that while in superficial lesions due to B. tuberculosis, ulceration is produced (lupus, p. 236), and in the soft tissues masses of granulation tissue (granuloma, p. 219), in bone the typical result will be a **Caries** (p. 532), and that according to whether liquefaction of the tissues from the toxins occurs, "pus" formation will (Caries Suppurativa) or will not (Caries Sicca) accompany the inflammatory process; while if much arterial disease has resulted, then considerable wedge-shaped areas of bone will necrose, so that the resulting sequestra will be infiltrated with granulation tissue and therefore be porous and friable, and found in the area in a partly absorbed condition (Caries Necrotica). These sequestra are quite different in appearance to those of acute septic osteitis. Tuberculous ones are light, spongy, eroded and greyish in colour ; septic ones dense, hard, thickened and white.

As in other bone infections, the bacilli enter usually by the nutrient artery, and therefore lodge in the capillary loops of the metaphysis of the long bones, where they find a suitable nidus for growth and where their increase is certainly aided, if not actually determined, by slight traumatism, of which there is frequently a history in such cases; more severe trauma produces sufficient inflammatory reaction to destroy the bacilli, seldom therefore being followed by tubercle.

Another route of invasion is from those branches of the circulus vasculosus, around the reflexion of the synovial membrane on the bone, which supply the epiphysis, periosteum and metaphysis, joint infection being an early sequel in infections of this type, which are particularly common in young children.

From the facts that infection is of low grade and liquefaction common it follows that partial or complete localisation often occurs, with the formation of chronic abscess (see p. 541), a condition frequently associated with tuberculous caries. As, however, the caries, by destroying the bone, prevents any sclerosis in the tissue around the abscess, this is seldom completely localised and usually progresses slowly, ultimately pointing along the line of least resistance, *i.e.*, generally through the epiphyseal line, and giving rise either to joint infection or a subperiosteal abscess, and subsequently to a discharging sinus leading to the bone. As in all tuberculous lesions, secondary pyogenic infection is very liable to supervene when a sinus is present, and then the original infection may be obliterated and the new bone laid down in regeneration be of the abundant coral-like appearance so typical of septic osteoperiostitis; a condition frequently seen in those old specimens in museums where sinuses are present, and where the osteoperiostitis around is obviously of the septic type.

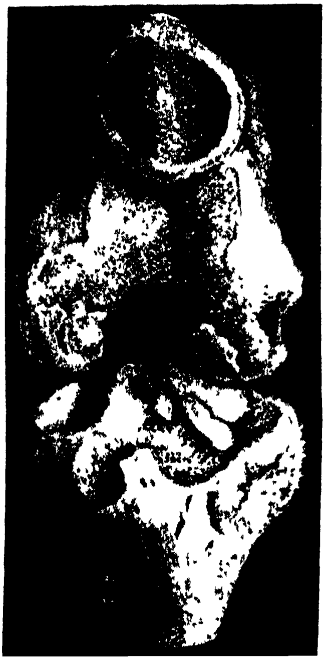


FIG. 267. Tuberculous caries with necrosis, showing the porous sequestra.

Apart from these cases, as already mentioned, the regenerative process stimulated by tuberculosis in bone is feeble and tends more to fibrosis than new bone formation; such new bone as is laid down is scanty in amount and sketchy in outline, giving rise to the slight feathery appearance so typically seen under the periosteum both in dried specimens and X-ray photographs of uncomplicated tuberculous osteitis.

As with pyogenic organisms, however, the tubercle bacillus may gain admission through the periosteal vessels, when a patch of superficial caries of the compact bone results, with the formation of a mass of granulation tissue, and ultimately a tuberculous abscess deep to the thickened and congested periosteum. Such an infection is by no means uncommon, and is usually seen in the ribs, sternum and flat bones of the skull and pelvis; it also occurs under the anterior common ligament of the vertebræ as a result of infection from mediastinal glands in children, and produces the diffuse form of spinal caries (Vol. II., Chapter III.).

Occasionally this type of lesion may invade the medulla and cause a generalised bone infection, which then commences in any area of the bone; moreover, in rare cases where the toxins are weak, a very intense osteoperiostitis may follow, and the regenerated bone is then not only widely distributed and very dense, but the whole bulk is much increased, the condition much more approaching that usually seen in syphilis of bone.

Lastly, in some short bones, such as the phalanges, tarsal and carpal bones and vertebræ, where the nutrient artery immediately breaks up and is widely distributed throughout the bone, the whole cancellous tissue and medulla are simultaneously invaded and converted into a mass of granulation tissue and carious bone, while a layer of new bone is laid down more or less uniformly under the whole periosteum ; hence the bone appears to be steadily expanding, a condition typically seen in tuberculous dactylitis, and by some authorities called *spina ventosa,* a name also applicable to this condition on those rare occasions when it occurs in long bones. A knowledge of the anatomy of the carpus and tarsus and the realisation of the fact that the bones are here literally all articular surfaces will suffice to show that joint infection will be an inevitable sequel and rapidly become generalised among the connected joint cavities in these cases ; while in the case of a vertebra the weakened body, unable to stand the body weight, collapses, giving rise to the typical angular deformity (Kyphosis, Vol. II., Chapter III.).

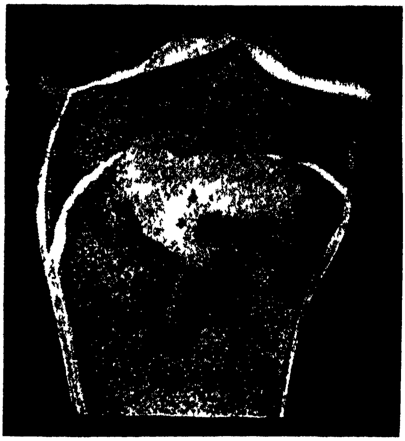


FIG. 268 Tuberculous abscess of the diaphysis of the head of the tibia invading the epiphyseal line

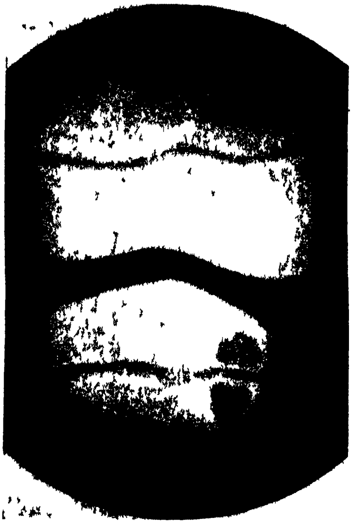


FIG. 269. Tuberculous abscess of the head of the tibia, invading the epiphysis (X-ray).

From the foregoing it will be realised that tuberculosis of bone may present clinically any one of four types :—

1. *Central osteitis,* affecting usually the metaphyses of long bones, frequently associated with Brodie's abscess, and almost inevitably leading to joint infection.

2. *Peripheral osteitis,* due to subperiosteal infection with formation of a superficial bone abscess, and not causing joint disease unless the lesion is situated deep to the synovial lining of a joint cavity.

3. *Spina ventosa,* occurring in short bones, where the invasion is generalised and the regenerative osteoperiostitis leads to apparent " expansion " of the thinned and carious bone.

4. *Sclerosing osteoperiostitis,* with increase both in density and bulk of the bone, a very rare condition in tuberculosis of bone.

The *clinical signs* of these conditions will vary somewhat, and it is well to discuss them separately.

(1) **Central Osteitis,** as already stated, produces but little inflammatory reaction, and so, though the soft tissues over the part may be rather swollen

and puffy if the bone is superficial, no actual thickening of the bone can be detected; nor is there any redness of the skin, though this frequently may be slightly warmer to the hand than that of the corresponding region on the other side of the body. The signs, generally speaking, are those of chronic bone abscess, save that there is no detectable increase in bulk of the affected bone; thus there is wasting and loss of tone of the muscles, with consequent flabbiness on handling, pain, worse after use, and tenderness over the affected area on percussion, with possibly a small serous effusion into the joint. The condition, however, may not manifest itself to the child's parents, nor indeed to the practitioner if unobservant, until the disease extends to the bone surface and either invades the joint or causes a tuberculous abscess in the soft parts.

X-ray examination should be resorted to in any doubtful case, and will show usually general rarefaction of the end of the bone, often with a clearer central area, where pus is present and a small amount of feathery subperiosteal new bone.

Treatment consists in immediate and complete immobilisation of the affected bone, best secured by efficient splinting with plaster of Paris, so as to fix the joints above and below and secure complete rest and muscle relaxation. This plaster will need removal and renewal at the end of a month, as muscle wasting consequent on disuse allows the splint to become loose, and thus prevents the essential complete immobility of the area. The second splint should be left on for six months after all pain has ceased, being watched to see no breakage or looseness develops, and may then be removed and replaced by some extension splint, *i.e.*, a walking caliper in the lower limb, which will allow of walking and faradisation. Massage is contra-indicated, and movements of the affected part should not be allowed for at least nine months after cessation of all pain. A very shrewd idea of the progress of the case can be formed by the fact that the pain ceases and the child's health and spirits improve, but it is wise to check this with monthly X-ray examination. Should pain continue, the usual reason is imperfect immobilisation, and the plaster should be examined carefully or renewed, but if this symptom still continues, and, above all, if X-ray films reveal the condition to be spreading toward the joint, then operative measures must be at once undertaken, the bone exposed, and the abscess and granulations curetted away, for even at the worst a sinus will result and the joint be preserved from infection.

In old-standing neglected cases, where sinuses exist or the joint is disorganised, amputation may be necessary, and this is urgently called for if secondary infection or amyloid disease is present.

Diagnosis. As will be seen from the physical signs, it may be very difficult to determine whether the joint is infected or if a pure bone lesion still exists alone. As the treatment is the same in both cases, it is not perhaps very essential that the diagnosis be made, but inasmuch as the prognosis is much better in pure bone disease as ankylosis of the joint is not likely to occur and free movement therefore may be expected, it may be a source of great comfort to anxious parents if an accurate diagnosis can be made. The points on which joint disease can be eliminated are, briefly, non-limitation of movement, absence of any muscle spasm, and an X-ray film showing a clear-cut joint line, with a normal clear space where the articular cartilage lies between the bony surfaces (Chapter XIX., p. 599).

The *prognosis* as regards the local condition is always serious, as even if the joint escapes infection there is a tendency to relapse, with subsequent joint invasion and sinus formation, as a result of which secondary septic infection and amyloid disease may develop. The coexistence of lung and bone disease in the same patient is of very grave significance—hence the importance of keeping surgical tuberculous cases apart from pulmonary cases during treatment and convalescence.

(2) **Peripheral Osteitis** may occur in any bone as a result of infection from the periosteal vessels, but is commoner in those bones with subcutaneous surfaces easily exposed to trauma, and thus is seen most often in the ribs, sternum, skull bones, tibia and ulna. The lesion starts insidiously with the formation of a mass of subperiosteal granulation tissue, which in the early stages may not cause any obvious caries of the underlying bone, though this always can be detected later. The condition usually progresses painlessly, and very often a painless, fluctuating swelling due to a tuberculous abscess is the first indication of the trouble.

If seen in the early stages a soft, painless swelling may be felt on the bone, usually ovoid and raised, and rarely with a bony ridge at its periphery in those cases where sufficient inflammation is present to lead to detectable osteoperiostitis; later liquefaction leads to the formation of a tuberculous abscess, which presents a slowly increasing ovoid, encapsuled and fluctuating swelling, fixed to the bone, but not to the overlying skin except in the very late cases, where it is pointing; this swelling, if very chronic, may be enclosed in so dense a fibrous capsule that a definite edge can be felt and rolled under the finger. The skin over the abscess is not reddened, nor is there any œdema or tenderness, but slight increase of heat usually can be detected, and in late cases, when the abscess is breaking through the integument, it is thinned and bluish; later a sinus, leading down to bone and presenting an œdematous button-like mass of granulation tissue protruding from its mouth, may be present, following discharge of the contents of the abscess.

An X-ray film should be taken always, and may show superficial caries of the bone, with a little feathery osteoperiostitis, but frequently nothing abnormal can be detected.

Treatment consists, if practicable, in excision of the diseased area in toto, and this can be carried out in the case of the ribs; but usually incision and free curettage, followed by swabbing of the bone with strong antiseptics, and closure of the wound in layers, are all that can be done. The results are on the whole good, but sinuses sometimes occur if the treatment has not been sufficiently drastic.

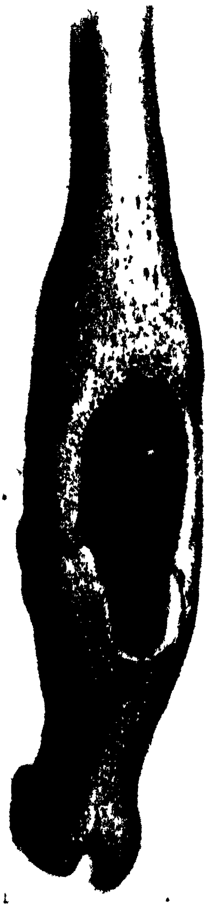


FIG. 270. Tuberculous osteitis of the ulna; "Spina ventosa."

Diagnosis. In the early stages the condition may be confused with periosteal sarcoma or osteitis fibrosa, but in both of these cases an X-ray film will clear up the diagnosis, there being always considerable new bone formation in sarcoma, and typical expansion, rarefaction and cyst formation in osteitis fibrosa. When an abscess is present this is very liable to be mistaken for a lipoma, but the lobulation of the latter, with its fixation to the skin and freedom from the bone, if subcutaneous, should prevent misdiagnosis in superficial bones; in the case of a parosteal lipoma (Chapter VIII., p. 193), however, the diagnosis is almost impossible unless the X-ray film reveals caries.

Prognosis is on the whole good, general infection of the bone being uncommon if the local condition is promptly treated. Should it occur, the condition becomes one of central tuberculous osteitis and must be treated accordingly.

(3) **Spina Ventosa.** This form of tuberculosis usually is seen only in short bones, typically in the phalanges of the fingers (tuberculous dactylitis) or toes, and in the tarsus, carpus and vertebræ, but occasionally may be met with in long bones, particularly the ulna and radius.

The condition of **Tuberculous Dactylitis** is commonly seen in the proximal phalanx of the hand of small children, but may occur in any phalanx and at any age, though rarely seen after adolescence. Ordinarily only one phalanx is affected, but tuberculous lesions may be present elsewhere in the body. The onset is gradual, with a diffuse fusiform thickening of the phalanx and some infiltration of the surrounding soft parts, while occasionally one end of the bone is more affected, usually the base where the epiphysis is situated. The overlying skin is normal, except in advanced cases, when it is thinned and blue, or where sinuses may be present, or the tendon sheaths or joints involved. Pain of a dull, aching character is often complained of, while a small child is fretful in consequence; there is no tenderness on handling the part. An X-ray film should be taken and will show diffuse caries, with a thin expanded shell of subperiosteal new bone.

Treatment consists in immobilisation by means of strapping over Scott's dressing or plaster of Paris, which in the case of small children should include the entire hand, and must always fix the wrist in slight hyperextension, the fingers being extended. Should this fail to arrest the disease the swelling should be incised, the bone opened and the carious interior thoroughly curetted out and swabbed with strong H_2O_2 or pure carbolic, and the wound closed, care being taken to support the shell of bone to prevent fracture occurring. Such treatment is often followed by retardation of bone growth, with consequent stunting of that segment of the finger, but this is not uncommonly a sequel in cases treated conservatively, and especially in those where the epiphysis at the phalangeal base is involved. In cases where the joint or finger is disorganised amputation may be called for, usually through the metacarpophalangeal joint.

Diagnosis may present difficulties, especially in adults, where *myeloma* may occur, or more commonly *chondroma*, which latter tends to be multiple; another fruitful source of error is callus formation following a fracture. X-ray pictures will, of course, at once establish the diagnosis. In children gummatous dactylitis may give rise to trouble in diagnosis, but in this condition generally several bones are affected, the Wassermann is positive, and the X-ray film shows marked osteosclerosis.

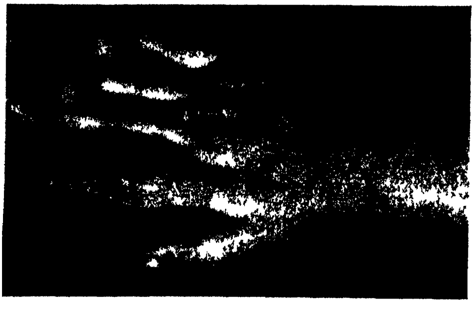


FIG. 271. Tuberculous dactylitis.

The treatment of all cases of this form of the disease is on the lines laid down in tuberculous dactylitis, but is, of course, modified by the situation of the bone affected. Thus in the *vertebral column* it is usually impossible to secure adequate rest, though this is attempted, both by external splintage with plaster of Paris jackets and beds, and internal splintage to fix the vertebral spines by bone grafts (Albee and Hibbs), while an excellent way in lower dorsal or lumbar cases is to nurse the patient on the abdomen, with the chest supported by pillows; this prevents deformity, and the stretched spinal muscles make an excellent splint. The caries, therefore, usually progresses, and as the weight of the body becomes too much for the thinned shell of bone which represents the vertebra, it collapses and the typical angular curve (kyphosis), so commonly seen in spinal caries (Pott's disease, Vol. II., Chapter III.), results; for the same reason tuberculous abscess is very common in connection with this form of the disease.

(4) **Sclerosing Osteoperiostitis,** with the formation of massive new bone, is usually seen only in the tibia, the whole of which is affected, the shaft assuming the thickened curved sabre-like appearance so commonly seen in tertiary syphilitic osteitis (p. 554), from which it is almost indistinguishable. Tuberculous disease of this type is so rare as only to deserve a passing mention, and follows a generalised medullary infection in adults, in whom it can be diagnosed only in the absence of a positive Wassermann reaction.

SYPHILIS OF BONE

As in other deep-seated tissues, the Treponema pallidum may cause inflammation by infecting bone, either in the secondary or tertiary stages of the disease, the infection being blood-borne, and thus most commonly occurring in the centre of the bone as in the case of other infections; but as will be shown, in the tertiary stage the disease tends to be localised in the middle of the bone shaft rather than at the metaphysis, because of the generalised obliterative endarteritis produced, which prevents the infection travelling to the ends of the bone. Epiphyseal and periosteal infections also occur.

The disease is met with both in congenital and acquired syphilis, though certain forms are more common in the hereditary disease, and in all cases the lesions tend to be symmetrical, the affected bone on one side of the body generally becoming involved three weeks or so in advance of the similarly infected bone on the other side.

(A) In *secondary syphilis* the lesions, as elsewhere, are usually transitory and leave no permanent effects from the temporary inflammatory reaction evoked:—

(*a*) Central infection of the bone occurs and is clinically manifested by *osteoscopic pains*, which are accompanied by local tenderness over the metaphysis and usually clear up in a few days; resolution is the rule, though occasionally a certain amount of sclerosis of the cancellous bone may be detected on X-ray examination.

(*b*) *Peripheral subperiosteal infection* also occurs fairly frequently, and results in the formation of a tender area on some portion of the surface of a bone, frequently the subcutaneous surface of the tibia, following some slight trauma; resolution usually occurs, but not infrequently a regenerative osteoperiostitis supervenes, and a raised localised nodule of hard subperiosteal bone persists (**Periosteal Node**), which, as the new bone laid down is often of the sclerosed type so commonly seen in syphilitic osteoperiostitis, may cause the patient considerable pain from pressure and congestion of the contents of the Haversian canals; this naturally will be more severe if the part gets hot, as when the patient is in bed or near a fire. These periosteal nodes may be regarded as late secondary or early tertiary manifestations.

Treatment. This consists in prompt general antisyphilitic measures (Chapter VI., p. 121), local treatment having no effect on new bone once laid down.

(B) *Tertiary syphilitic infection* usually assumes the diffuse infiltrating form in bones, but localised gummata occur, and it is interesting to note that whereas the commoner diffuse osteitis is usually of the central type and produces a very marked sclerosing osteoperiostitis, the rarer localised gummatous lesion is nearly always of the peripheral subperiosteal variety and tends to give rise to a caries with but little osteoperiosteal reaction; the disease thus forms a marked contrast to tuberculosis in the common type of bone reaction called forth in response to the treponemal infection.

(1) **Generalised gummatous infiltration** (Chapter VI., p. 117) is, as already stated, the type of infection commonly seen in bone and is usually due to widespread invasion of the blood vessels by the treponema, but as obliterative endarteritis is an early and constant sequel of this infection, the disease tends to be localised to the hard bone in the centre of the shaft and is prevented from spreading to the cancellous bone of the metaphysis to any marked extent by the vascular thrombosis and obliteration evoked by the infection; hence the main stress of the infection and subsequent repair with dense sclerosis, as in other tissues similarly affected (Chapter VI., p. 120), tends to be mainly in the compact bone of the central area of the shaft; this presents an enormously thickened and dense white ivory-like appearance, thickest in bulk at the centre, and tapering off toward each end, owing to deposit of dense new bone in the Haversian canals and under the periosteum. There is, at the same time, a certain amount of invasion of the medullary canal, both by this new bone and by the treponema itself, with subsequent reparative osteitis, which leads to partial or more or less complete replacement of the medulla by dense cancellous bone, with obliteration of the normal canal and its contents. The Haversian canals become partly or completely obliterated in this process of *sclerosing osteoperiostitis*, and in consequence of this and the obliterative endarteritis, the blood supply is so poor that necrosis may supervene spontaneously; should infection occur, as in the mouth and nasal cavities, this will be an inevitable and early result of the lowered vitality of the bone, and is likely to be extensive, the resulting sequestrum being considerably harder and denser than that seen in the case of normal bone, and separating very much more slowly, as there is insufficient blood supply to form an adequate line of demarcation; indeed, as in senile gangrene (Chapter VII., p. 156), a vicious circle may be set up and the condition spread slowly, as is not infrequently seen in gummatous osteitis of the skull.

In addition this sclerosis of the canals, by causing pressure on the contained nerves, leads to severe pain, which, of course, will become worse if the vessels in the canals become congested.

On the periphery of the new bone a certain amount of subperiosteal activity goes on, so that the outer surface becomes slightly roughened, the new bone presenting a regular, finely lined appearance not unlike the surface of a file, and on section looking as though a layer of cement had been laid down around the original bone surface.

The disease occurs in both the acquired and congenital forms of the disease, but the latter form is better dealt with under syphilitic epiphysitis (p. 556).

In the long bones this central form of the disease is characteristically seen in the tibia, but may occur in the femur, humerus, radius and ulna, or any other bones; both sides are usually affected, the second bone becoming involved at a somewhat later date (three weeks to a month) and always showing slightly less regenerative osteoperiostitis than the originally infected bone, as is indeed the case in all tissues affected with this form of syphilis.

Clinically there is a diffuse thickening of the affected bone, most marked in the centre, while it may become bowed apparently, with alteration of the regular outline, roughness and loss of sharp margins, which become rounded off. In addition there is severe and persistent boring pain, which is a most distressing symptom, and is worse if any vascular congestion of the leg occurs; for which reason it usually keeps the patient awake by becoming worse at night when the legs get warm in bed, and indeed, many such patients will sleep with the limb out of the clothes, and avoid the proximity of a fire for a like reason. An X-ray film shows generalised thickening of the whole shaft, denser at the centre, and partial or complete obliteration of the medullary canal and replacement of this normally clear area by bone, the shadow being much darker than normal, owing to the density of the new bone (Fig. 274).

Treatment in the earlier stages consists in antisyphilitic treatment and the free administration of iodide of potassium in the hope of dissolving any dead albuminous gummatous material and relieving pressure on vessels and nerves; it is, however, a forlorn hope and seldom gives more than temporary relief. In the later stages the dense bone must be gouged away and channelled into the medullary canal, when temporary relief will be experienced for a few months, but the ultimate outlook is bad, and amputation has not infrequently to be resorted to in order to save the patient from suicide or madness resultant on the continual pain.

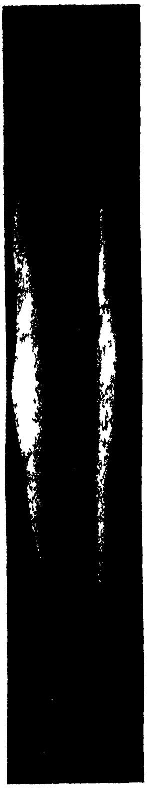


FIG. 272. Syphilitic osteitis with gummatous osteoperiostitis of the tibia.

Diagnosis. The diagnosis of this condition may present some difficulty on superficial examination, but usually can be definitely established by careful attention to physical signs and always by X-ray examination and the Wassermann reaction. From sarcoma the condition may be differentiated by its affecting the central area of the bone and not the extremities, by its uniform dense hardness, and the fact that the corresponding bone is usually affected on the other side; from chronic septic osteitis, by the gradual onset and absence of cloacæ; from Brodie's abscess by being in the centre of the shaft usually, and by the absence of a clear central area in an X-ray film; and from hyperplastic tuberculous osteitis by the extreme rarity of this condition and the negative Wasserman reaction in tuberculosis. In osteitis deformans (p. 564) the X-ray film shows bending and porosity of the thickened bones.

In the skull diffuse gummatous osteitis is met with not infrequently, both in the inherited form, where it results in Parrot's nodes, and in acquired syphilis, in which latter form of the disease it causes great thickening of the calvarium and not infrequently results in necrosis of large areas of the hard bone; this condition is much aggravated if, as often occurs, an overlying gumma of the scalp breaks down and leaves the underlying sequestrum exposed to secondary infection. Such sequestra usually affect the inner table more extensively than the outer, and may remain for years partly or completely separated, lying exposed to the air, and consequently bare and blackened, in a sea of pus, meningitis not infrequently supervening. This condition is not now seen as frequently as it used to be, but milder forms of the disease still occur, with neuralgia and palsy of orbital and facial muscles from pressure on their motor nerves as these emerge through the narrowed foramina in the skull. "Snuffles," with consequent depression of the bridge of the nose after necrosis, so characteristically seen in congenital syphilitics, and perforations of the hard palate and nasal septum, in both congenital and acquired cases, are good illustrations of the destruction wrought by necrosis in this form of the disease when sepsis is superadded.

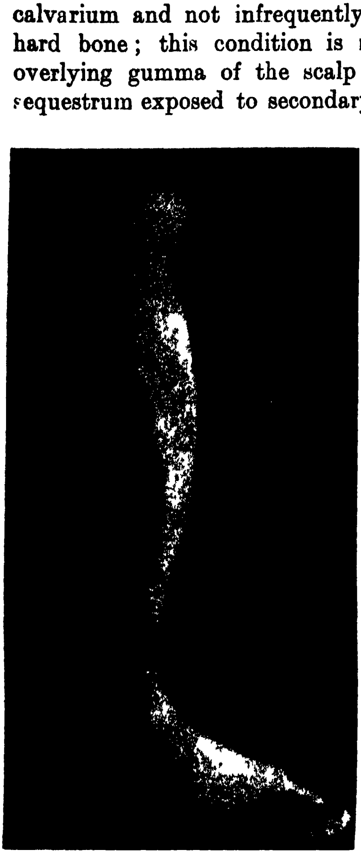


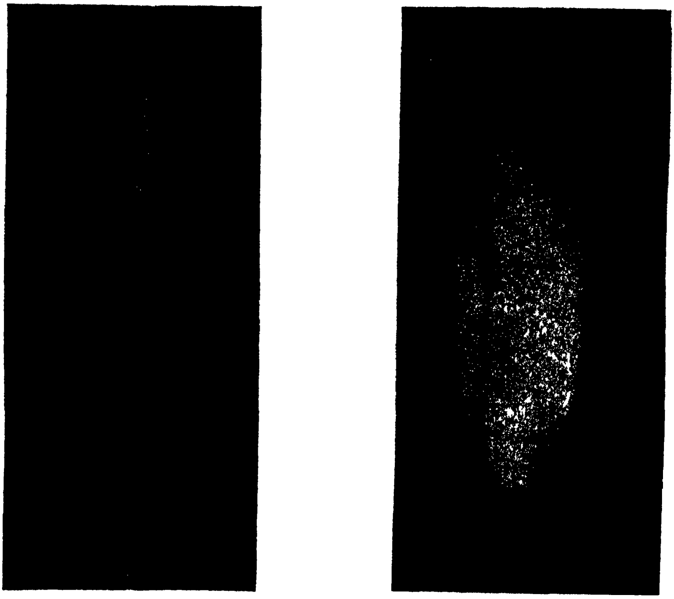
FIG. 273. Diffuse gummatous osteitis of the tibia (Sabre tibia).

(2) **Localised Central Osteitis** due to tertiary syphilis is but rarely seen, and when it occurs results either in a carious area from gummatous infiltration, usually met with in the cancellous bone at the ends of long bones, or in the formation of an actual cavity due to disintegration of a gumma and absorption of the dead tissue, with a fairly widespread reactionary sclerosing osteitis, in which case a Brodie's abscess results (p. 542).

The condition is very rare and easily confounded with a tuberculous or septic Brodie's abscess, from which diseases it can be diagnosed by the Wassermann reaction and the evidence of syphilis elsewhere. In the form in which a central gumma breaks down, sarcoma may be suspected and can be diagnosed by means of an X-ray film.

(3) **Peripheral Osteitis** may be of the diffuse form, when general thickening of the bone results, as is often seen as an accompaniment to central osteitis, or it may be more or less localised to one area, when if there is much reactionary osteoperiostitis, "periosteal nodes" result, which present as localised subperiosteal thickenings, fading at the edges into the surrounding bone. If, as is more usual, the bone reaction is slight, localised areas of caries, with subsequent pitting of the bone surface, are the consequence, a condition which is sometimes seen in the skull bones in both congenital and acquired syphilis, where it goes by the name of "craniotabes."

(4) **Syphilitic Epiphysitis** is by no means rare in the congenital type of the disease, and may occur in early infancy or childhood, resulting, if untreated,



A. B.

FIG 274 X-ray film of Fig 273. A. Lateral. B. Antero-posterior view.

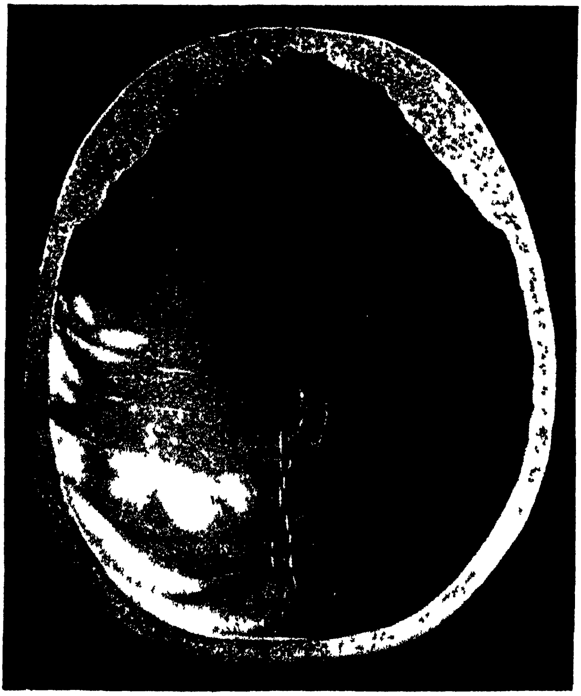


FIG. 275. Diffuse gummatous infection of the frontal region of the skull.

in separation of the epiphysis, or stunting of the bone growth, from destruction of the ossific nucleus and premature synostosis with the shaft centre, which is usually similarly affected; this latter condition is in reality a form of central osteitis, but will be dealt with here as it is closely allied to epiphysitis and usually occurs with it. Clutton's Joints (Chapter XIX., p. 605) are a frequent accompaniment of this condition.

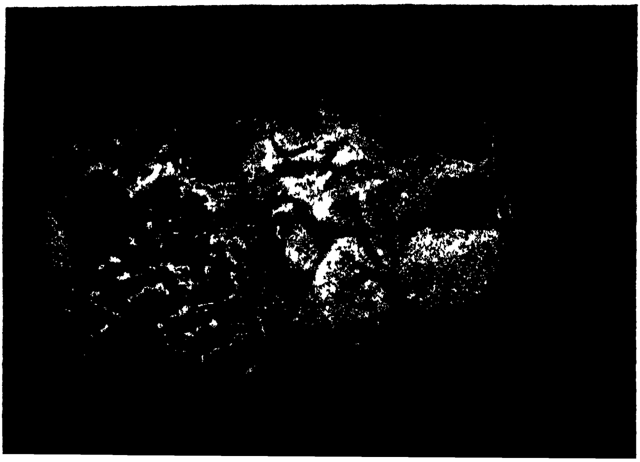


FIG. 276. Localised gummata of the skull with necrosis of bone. Some of the sequestra are darkened from exposure to the air.

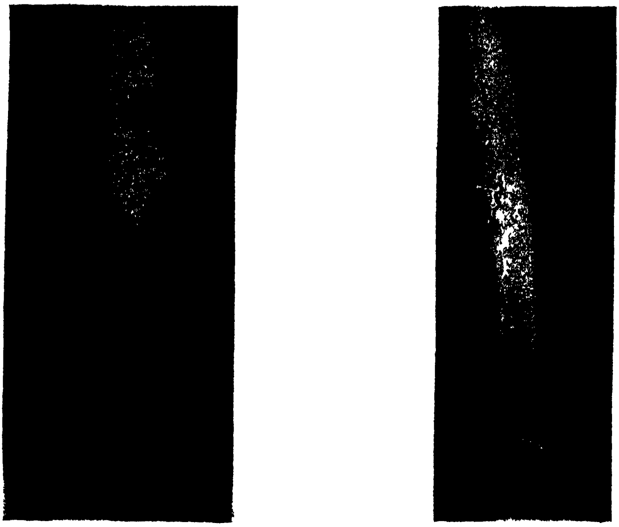


FIG. 277. Localised gumma (Brodie's abscess) of the radius. Note the surrounding sclerosis.

The invasion occurs *via* the nutrient artery and circulus vasculosus, an obliterative endarteritis of the capillary vessels causing diffuse gummatous infiltration and death of the growing tissue, with its replacement by a mass of yellowish gummatous material, which can be detected with the naked eye on section, replacing the normal, intensely red, vascular tissue on either side of the epiphyseal line; this material may liquefy, with consequent separation of the epiphysis, a condition not uncommon in infants, or if it is more chronic, absorption with fibrosis, premature synostosis and consequent dwarfing occur.

Clinically the affected bone is usually painful and tender (one form of growing pain in children), and should separation occur, all the signs of a separated epiphysis will be present (Chapter XIV., p. 411). Effusion into the neighbouring joint is not uncommon, and an X-ray film may show some deformity of the ossific nuclei; it is conceivable that some cases of Perthes' disease (p. 545) are due to arrested gummatous epiphysitis, while Brodie's abscesses may undoubtedly result from localisation of the disease in the metaphysis.

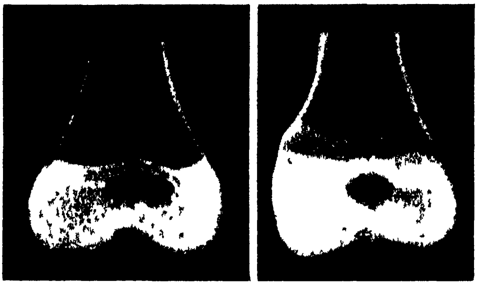


FIG. 278. A. Normal lower end of the femur in an infant. B. Gummatous infiltration of the epiphyseal line and nucleus of the femur.

The *diagnosis* has to be made from scurvy (p. 572), which is done by noting absence of hæmorrhage, both from the gums and elsewhere, and the presence of a positive Wassermann reaction and other stigmata of syphilis; from rheumatism, by absence of temperature and cardiac signs; from tuberculosis, which may be difficult in older children, by an X-ray film, the Wassermann reaction, and the affection of other bones; from acute osteitis by absence of extreme tenderness and illness, except where separation has occurred, when the limb will be very tender and painful, but no temperature or septicæmia will be noted; and lastly, if separation has occurred, from fracture or traumatic separation of the bone, by absence of definite injury and the presence of syphilitic stigmata.

Treatment consists in prompt and thorough antisyphilitic treatment, with reduction and splintage if any epiphyseal displacement has occurred, either clinically or as shown on X-ray examination.

PARASITIC DISEASE OF BONE

The Tænia echinococcus is occasionally met with in bones in the cystic form, the infection usually occurring through the nutrient artery and being, therefore, central in type. As already noted (Chapter VI., p. 137), the multiplication is of the exogenous type in these bone infections, as in the lung; a series of separate cysts of small size occupy the medullary canal, no surrounding mother cyst existing. In time the pressure of the multiplying cysts causes severe disturbance of the nutrition of the bone, which atrophies in consequence, so that pathological fracture is prone to occur, while the irritation of the periosteal vessels causes the laying down of a thin layer of peripheral bone, so that an apparent fusiform expansion is caused.

Clinically there may be a history of hydatid disease elsewhere, and urticarial rashes will follow the escape of fluid from a cyst punctured by bone spicules if a fracture occurs. Examination of the blood will reveal eosinophilia, and the agglutination and Casoni tests for hydatid fluid will be positive (Chapter VI., p. 138).

Locally the affected bone will be noticed to present a general fusiform enlargement, and sometimes a soft, fluctuating area or egg-shell crackling can be detected. An X-ray picture will reveal a cavity in which cyst walls may be outlined and show the thinned and expanded osteal shell.

The *diagnosis* is from endosteal sarcoma, and if fracture occurs, from an ordinary injury leading thereto in a normal bone. An X-ray film will make the diagnosis obvious at once.

Treatment consists in opening the medullary cavity, removing the cysts, and packing with 4 per cent. formalin for twenty-four hours. If the bone is sufficiently rigid to support the part, splintage is not required; in other cases it will be needed. Recurrence is uncommon after this treatment, but occasionally in late cases with a disorganised limb amputation is advisable.

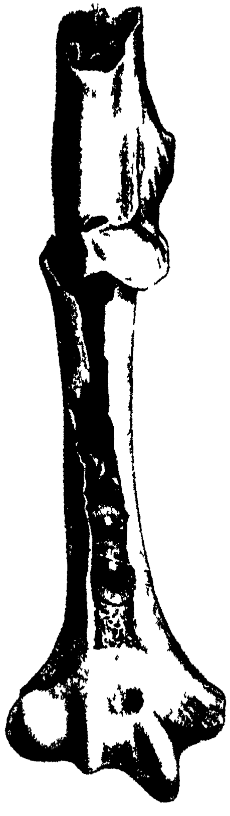


FIG. 279. Hydatid cysts in the humerus, with pathological fracture

GENERAL DISEASES AFFECTING BONE

There are a considerable number of general diseases, the pathology of which is obscure, in which apparently, either from some lack of endocrine gland secretions (as in acromegaly and osteitis deformans) or overaction of one or more parathyroids (as in diffuse myelomatosis and osteitis fibrosa) or from nutritional deficiencies in certain vitamins (rickets), the calcium metabolism in the body becomes disturbed, and in consequence decalcification of existing bone occurs to supply the deficiency of that salt in the other body tissues. So far as the bony system is concerned this results in softening of the decalcified bones, which become bent and distorted from pressure, body weight, and muscle pull, so that gross skeletal deformities may result; furthermore there is in most cases a compensatory hypertrophy of the bone, an attempt to compensate by increased bulk for lost stability, as is well seen in rickets, osteitis deformans, etc. But there is another group in which this reaction is absent or very ill developed, as in osteitis fibrosa, mollities ossium, etc., so that it will be seen that such cases fall into two main groups from a clinical standpoint and will be dealt with thus.

There is yet a third class of lesion affecting the bones, namely, certain blood diseases, notably scurvy, where hæmorrhages may occur in the medulla, or under the periosteum, as elsewhere in the body.

(A) *Decalcifying Osteitis, with compensatory Hypertrophy.*

RICKETS

Rickets is a disease met with typically in children from six months to two years of age, but it may occur earlier or later; the condition results partly from the absence of fats and vitamins D and A from the diet, causing deficiency of calcium salts, and partly from overcrowding, dirt and absence of sunlight; hence the disease is seen more commonly among the poor in overcrowded slums in cities, and is more prone to occur in wet and foggy seasons. A somewhat similar disease may occur at adolescence (*adolescent rickets*), or among children, young adults, and even adults, as the result of prolonged deprivation of fats (*famine rickets*), but as in both these conditions little or no attempt is made at compensatory regeneration, they will be described with osteomalacia (p. 566), which condition they closely resemble. *Fœtal rickets* is also described as occurring in utero, but is a doubtful entity, most of the cases being probably due to osteogenesis imperfecta (q.v., p. 570). *Renal rickets*, which occurs in young children with chronic nephritic degeneration, is described on p. 569, and has nothing in common with true rickets.

Clinically the disease shows two stages :—

(1) The onset of rickets is gradual and seldom before the age of ten months; the child becomes irritable, restless, and sweats about the head at night, while there is a marked tendency to gastro-enteritis and bronchitis. The baby is usually rather fat and flabby, but may be emaciated, especially if there is much diarrhœa ; convulsions may form a distressing and alarming symptom and laryngeal spasm (laryngismus stridulus or croup) may occur at nights. On examination the child is found to be lethargic and marked hypotonus of muscle can be demonstrated by the easy and painless hyperextension of the joints, and the marked disinclination of children of a year upwards to walk ; the abdomen is full and prominent, the spleen palpable, and often the liver also, while the chest is retracted, especially along the line of diaphragmatic attachment, where it is drawn in, forming " Harrison's sulcus." Dentition is much delayed and irregular after the fourth month, the teeth when they appear being small and deficient in enamel, so that they soon decay. This is the early stage and may be called the " general " stage, as apart from the " osseous " stage, which supervenes in a few weeks.

(2) The osseous system soon becomes affected, the bones, especially in the region of the epiphyseal lines, being tender and swollen, but at the same time softened, so that bending and deformity occur as a result of pressure or muscle pull, *i.e.*, Harrison's sulcus in the chest. Thus bowing of the tibiæ and femora, with consequent production of genu valgum and varum, or coxa vara, are common, and yielding of the softened pelvic bones to the body weight results in the characteristic flattening of the pelvis, which may prove in the female a great difficulty in childbirth in later life. Other deformities, such as kyphosis, scoliosis, and cubitus varus and valgus, may occur. It is characteristic of the deformities of rickets that the bones always maintain their transverse outline, *i.e.*, sharp margins remain intact as in the subcutaneous border of the tibia, an important point in differentiating in later life between rickety deformities and those due to syphilis or sepsis, where the sharp outline is lost.

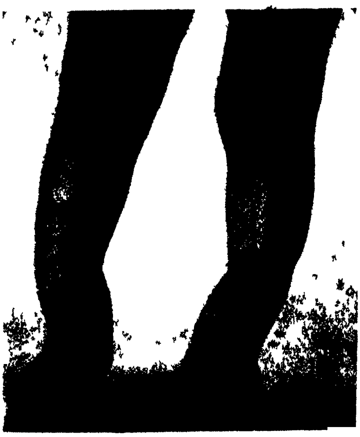


FIG. 280. Rickety " bends."

In this stage the bones are so softened that they can be welded by the hand of the surgeon and cut with a knife; moreover, should fracture occur, the softened bone bends and snaps on the convexity like a green stick, which gives it the name of a "greenstick fracture" (see p. 405). The epiphyseal enlargement is due to the fact that the main stress of the disease falls on the new bone at the metaphysis, which is laid down in a very irregular manner; columns and islets of cartilage project up among the new-formed bone, which is very porous and poorly calcified, being indeed fibrous for a considerable area: thus the epiphyseal line on section looks broader than normal and shows irregularity of the cartilage, islets of which, cut off among the new bone of the shaft, may persist and give rise to chondromata or cancellous osteomata (Chapter VIII., p. 203) in later life.

Clinically the *enlargement of the epiphyses* is easily visible and gives rise to the "rickety rosary" at the costochondral junctions of the ribs, and to marked thickening of the ends of the bent long bones in the region of the joints, this being very noticeable in the case of the lower end of the radius and tibia; in the skull thickening of the frontal and parietal bones leads to bossing, somewhat resembling that seen in congenital syphilis, and the retarded growth results in delayed closing of the fontanelles. This is best seen in the case of the anterior one, which is unduly large in infancy, and remains unclosed for six to nine months later than the age of eighteen months, which is the latest it should be patent normally.

Later, as the acute stage passes, new bone is laid down in considerable quantities in and around the affected areas, which therefore appear abnormally large and dense on X-ray examination, but which show persistent deformity; in the case of the long bones, such as the femur, compensatory buttressing in the region of the linea aspera, *i.e.*, the concavity, may occur, and the prominence of the epiphyseal regions thus may be masked partly, though it usually can be detected even in adult life; similarly the deformities persist and the whole stature tends to be stunted as a result of interference with and damage to the epiphysis in infancy, the condition in extreme cases resulting in "rickety dwarfism." This can be recognised by the heavy, bowed lower extremities, often short in comparison with the rest of the body, the square head, with a normal bridge to the nose, and the persistence of the thoracic deformities.

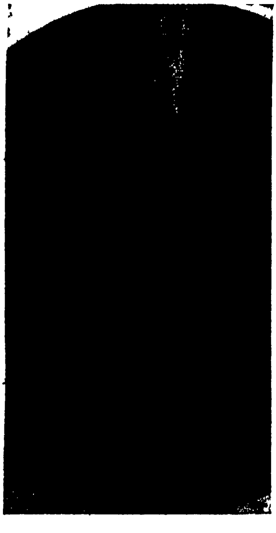


FIG. 281. Rickets.

Treatment. It is usually to cure the osseous deformities resulting from rickets that the surgeon is called in, and he should then take immediate steps to ascertain if the disease is still active; this is done by eliciting if the general signs described are presents in which case general treatment of the disease must be undertaken promptly and only manipulative surgery indulged in for the cure of deformities. In the acute or active stages the child must be given ample space, fresh air and sunlight, for which ultra-violet rays, to which it must be exposed naked, can be substituted in wet and foggy weather; a careful dietary must be prescribed, in which ample fats, best given in the form of cod-liver oil, and fruit juice are included. It is well to hand the child to the care of a children's physician in this respect. Bony deformities must be treated energetically by gentle and regular manipulation, if necessary under anæsthesia, though this should be avoided if possible because of the tendency to respiratory complications, with efficient splintage in between to maintain the bones in the corrected position. Massage and faradism are of great value in restoring muscle tone and maintaining the nutrition of the splinted limbs, which are best fixed in plaster of Paris, as this cannot slip like wooden splints.

Open operations should be undertaken only after all signs of active rickets have ceased, and as a general rule it may be laid down that no osteotomy should be performed before the child is six years of age. Linear or cuneiform osteotomy usually will then have to be resorted to, to correct angulation in the curved long bones, the incision and type used varying with the situation of the deformity (Chapter XXI., p. 715).

Diagnosis is usually easy, but *congenital syphilis*, which it should be remembered may be concurrent with rickets, may cause some slight difficulty, though it usually manifests itself much earlier in the infant's life (one to three months), and the child is always marasmic and has a peculiarly wrinkled, monkey-like facies.

When the two diseases are associated some difficulty may occur in sorting out the symptoms due to each, but if treatment be given for both, rapid improvement results. *Infantile scurvy* (p. 572) also may give rise to difficulty in diagnosis, but the disease occurs usually in the children of the well-to-do, fed on patent foods, and the gums are always raw, bleeding and spongy. *Achondroplasia* is most likely to cause difficulty, but here the sunken nose bridge, synostosed epiphyses (as seen by X-ray examination), trident hand, and generally bright and healthy condition of the child will point to a correct diagnosis.

ACHONDROPLASIA

Achondroplasia is a by no means uncommon condition, met with often in one child of a large family but not apparently hereditary, in which premature ossification of the metaphyses of the cartilage bones and their early synostosis with the normal epiphyses result in dwarfing of the skeleton; such growth as occurs takes place in the epiphyses of the long bones, which thus appear enlarged, and also subperiosteally. The membrane bones develop normally, hence the face and vault of the skull appear too large for the dwarf, but the premature ossification of the sphenoid results in depression of the bridge of the nose, which thus presents a saddle-shaped appearance like that seen in congenital syphilis. The child develops normally and is healthy and of normal mentality, though much stunted in growth. The condition may be recognised by the large but not bossed head, broad hands with tapering spindle fingers, the ends of the third and fourth diverging and so forming with the thumb the typical " trident hand," and the extraordinary way the child or adult rises straight up from a sitting to a standing posture without bending the knees, an acquirement which often leads to these cases becoming professional comedians.

No treatment is necessary or of any avail.

As already stated, the condition is most likely to be confused with rickets or congenital syphilis, from which it can be distinguished readily by a careful attention to the physical signs, with a special reference to the points enumerated above, and the bright, healthy condition of the child.

OSTEITIS DEFORMANS

Osteitis deformans, first described by Sir James Paget, and therefore often known as " Paget's disease," is met with in elderly people, more often males than females, and is characterised by a preliminary decalcifying osteitis, which leads to deformities of the bones, and is succeeded by hypertrophy of the affected bones, which later become calcified, and so regain rigidity. The new bone laid down is, however, of a characteristic porous and chalky appearance, and the dried specimens shed a white powdery dust, which can be seen accumulating in the specimen jar, and is pathognomonic of the condition ; the whole girth of the bone is much increased, though this is often localised to

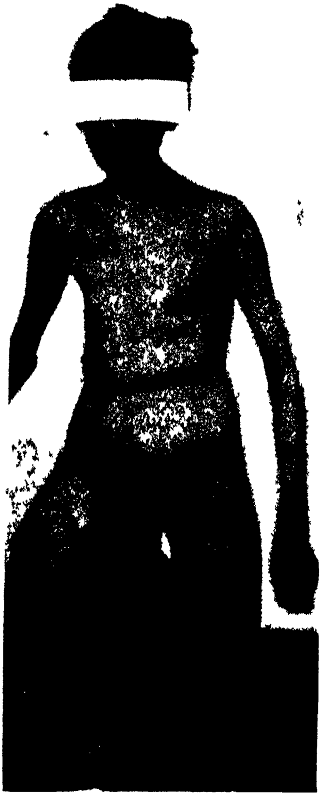


FIG. 282 Osteitis deformans with sarcoma of the right femur.

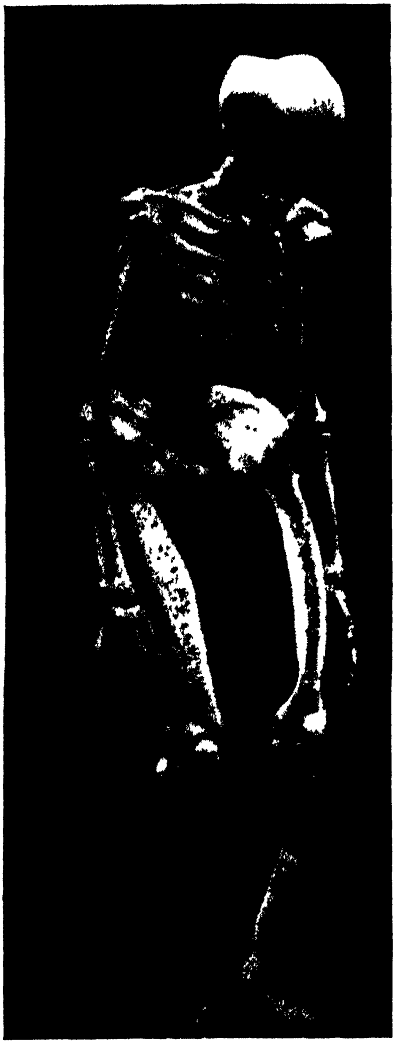


FIG. 283. Skeleton of an advanced case of osteitis deformans. Note the kyphosis shown in the reflection.

the portion of the shaft affected, and the medullary cavity may be obliterated completely in severe cases.

The affected bones, usually the femora, tibiæ, skull bones, vertebræ, pelvis, clavicles, and more rarely humeri, radii and ribs, are much thickened, bowed and distorted by the muscle pull and body weight; thus coxa vara is common, and kyphosis is met with not infrequently; the skull bones may be thickened enormously, the sutures obscured and the foraminæ narrowed, while the whole bone presents a homogeneous crumbling mass on section, the normal distinction of the inner and outer tables and diploë having disappeared. In the case of the long bones the disease may affect a part of the length of the shaft only, and although the medullary cavity is distinct, and even enlarged in the early stages, it becomes obliterated in advanced cases, or if syphilis is also present. There is a great tendency for sarcomata to develop in the affected bones, usually of the central variety, and spindle-celled; but they may be myeloid in type, in which case they are frequently multiple, and may permeate throughout the osseous system, a condition more frequently met with on the Continent than in this country, and often associated with the presence of Bence-Jones albumose in the urine (Chapter VIII., p. 214).

Clinically the disease is often discovered accidentally, but the patient may complain of severe pain in the affected bones, or that he has increasing difficulty in finding hats of a size sufficient to fit his enlarging skull. When fully developed the attitude and appearance are characteristic; the head is held forward and the body stoops forward as a result of the kyphosis and stiffness of the vertebral column secondary to its involvement, which attitude combined with the bowing of the lower limbs makes the arms appear unduly long and gives an ape-like pose to the individual. The muscles are usually wasted and the enlarged bones easily visible, those of the lower limbs being most deformed, while the head is dome-shaped and the veins unduly prominent in the scalp. Owing to the almost constant presence of coxa vara the lower limbs are everted and rather separated, the knees being slightly flexed; occasionally a prominent localised swelling on one bone raises the suspicion of a developing sarcoma. Rarely fractures may occur spontaneously in the affected bones.

X-ray photographs are typical, the bone showing thickening of bulk but rarefaction of the compact bone, and the presence of numerous thickened trabeculæ in the medullary space. Sarcomata, when present, usually show evidence of ossification, but otherwise present the appearance characteristic of endosteal tumours (Chapter VIII. and p. 580).

Treatment is of little avail; some improvement follows the administration of aluminium acetate or Thyroid. sicc. gr. i, t.d.s., especially relief of pain, and other endocrine extracts have been recommended. A high calcifying diet should be given, milk, egg yolk and cod liver oil especially, but its value is dubious, as the calcium metabolism is normal Recently it

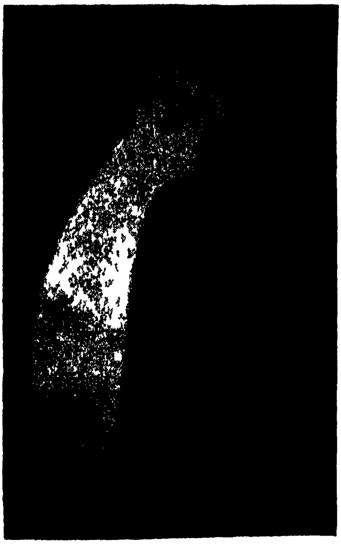


FIG. 284. Femur and pelvis in osteitis deformans.

has been found that ultra-violet rays given in *regular* daily doses over affected bones, for prolonged periods even up to a year or more, not only relieve pain but in early cases even cause a return to normal structure of the bone as judged by X-ray pictures. The disease is, however, steadily progressive, death usually resulting from sarcomatosis or some pulmonary complication, but not for many years.

If a sarcoma is present as a single tumour, amputation should be carried out, but metastases are common.

ACROMEGALY

Acromegaly is an uncommon condition usually occurring in young adults, and due to overgrowth or tumour of the anterior lobe of the pituitary body, the hypersecretion of which gland results in definite increase in the bony skeleton, most noticeable in the face and hands, though in some cases considerable increase in stature accompanies the appearance of these deformities.

The hands and fingers become much thickened and broadened, but not elongated, and appear, therefore, fat and clumsy; in the face the forehead and orbital ridges become prominent, the nose enlarged and fleshy, the jaw prognathous and heavy, and the lower lip thickened and hanging, the whole face presenting a heavy and elongated appearance. Minor deformities of the spine and sternum also may be detected, and the feet, like the hands, become broadened and spud-like. There is usually lassitude, a tendency to eat and sleep heavily, while interference with speech, marked loss of sexual power, headache and optic neuritis, with lessening of the visual field, are not uncommon.

X-ray films show the sella turcica to be enlarged, and the affected bones are thickened and denser than normal.

Treatment is of little value; thyroid has been tried with some success, and if a pituitary tumour is present its removal may be accomplished and at times will cause improvement (Chapter I., Vol. II.), but the prognosis is very poor.

The *diagnosis* is from myxœdema where, however, the skin is thick and coarse, achondroplasia, where dwarfing is present, and osteitis deformans, which comes on in old age, though none of these should cause any difficulty if a careful examination be made.

HYPERTROPHIC PULMONARY OSTEOARTHROPATHY

This is a condition met with secondarily to chronic pulmonary diseases, such as tubercle or bronchiectasis, though occasionally met with in cases of congenital heart lesions or even in otherwise healthy people. New bone is deposited around the periphery of the phalanges, especially the distal ones, of the fingers, which become "clubbed," presenting a drum-tick-like appearance, with the nails convex and curved forwards. Osseous changes also may occur at the lower ends of the radius and ulna, or tibia and fibula, which can be felt thickened, and are often associated with transient relapsing effusions into the wrist and ankle joints.

(B) *Decalcifying Osteitis without compensatory Hypertrophy.*

OSTEOMALACIA

This is an uncommon disease met with usually in pregnant women, but rarely seen in males; it is characterised by absorption of calcium from the hard and cancellous bone, which becomes replaced by a fibrous framework, more condensed in the subperiosteal region; the medulla becomes very vascular, and hæmorrhages are by no means uncommon and result in cystic spaces forming in the medullary canal. The bones chiefly affected are the pelvis and vertebræ, but long bones may be involved; owing to the loss of calcium salts the bones are soft and bend easily, hence deformity results, the most characteristic being the triradiate pelvis; the bone also cuts easily with a knife, and fractures of the greenstick type are not uncommon, attempts at repair being feeble or absent. As in rickets, calcium phosphate is absorbed from the bone to supply the deficiency due to non-absorption of these elements from the gut, and their excretion in the urine from the blood stream. Blood calcium is low, but much is excreted in the urine.

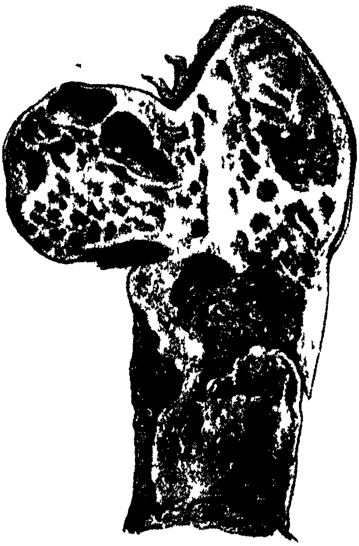


FIG. 285. Section through the upper end of the femur in osteomalacia.

Owing to the softened bones the patient is unable to stand upright, and there is great muscle weakness—death frequently resulting from cardiac failure or respiratory disease.

The disease progresses with pregnancy and does not seem benefited by abortion, though some authorities claim that good results follow oöphorectomy. Cæsarean section should be resorted to to escape the exertion of labour and consequent risk of cardiac failure. Should pain be present opiates must be administered. A diet rich in vitamin D is of some benefit.

FAMINE RICKETS

This is a disease met with as a result of deprivation of fats for long periods, which is especially severe in infants and adolescents. *Clinically* the disease is almost exactly similar to osteomalacia and the pathological changes in the bones are almost identical. The disease was very prevalent in Vienna towards the end of the last war and thereafter, but was distinguished easily from osteomalacia by the rapid improvement which followed the administration of fats. X-ray films show, as in osteomalacia, general absorption of the bone and deformities, and in children and adolescents changes in the metaphysis of a type similar to those noted in rickets (p. 562) are observed.

Diagnosis. Care must be taken to distinguish the condition from that met with after prolonged scurvy due to deprivation for long periods of fruit and vegetables, where bone absorption takes place to a lesser degree, and where a characteristic cone-shaped dense area persists at the metaphysis.

The *treatment* consists in the giving of fats and cod-liver oil, fresh meat and other foods rich in vitamins A and D, air and sunlight being valuable accessories to the fat diet. Should there be any suspicion of scurvy fresh vegetables and fruit juice must be added to the diet.

Marked improvement may be looked for in from six weeks to three months.

Indications for the Differential Diagnosis of certain Bone Diseases in the Adult (after Hunter).

	Radiographic Examination	Blood Examination.			Urinary Examination.	Time of Onset.
		Calcium in Serum.	Phosphorus in Plasma.	Phosphatase.		
Generalised osteitis fibrosa cystica.	Involves many bones. Multiple cystic areas with little sclerosis. Cysts and osteoclastomata may extend along or may expand the bone. Diminished density of bone shadows.	High, usually above 13 mg. per 100 c.cm.	Low, usually below 3 mg. per 100 c.cm.	High.	Calcium and phosphorus many times higher than normal, even on low calcium diet.	Early adult life and later—20 up to 55.
Local osteitis fibrosa.	Often only one bone affected. Spacing out of lamellæ to form cystic areas.	Normal.	Normal.	Normal.	Calcium and phosphorus excretion normal.	Chiefly in adolescence.
Osteitis deformans.	Bones thickened. May affect only one bone, but generally several. Skull usually thickened and woolly. Pelvis often first affected. Bone structure eventually lost, and acquires more or less uniform density.	Normal.	Normal.	High.	Calcium and phosphorus excretion normal.	Later life—45 to 65.
Osteomalacia.	General rarefaction of bones and structure considerably lost. Shafts of long bones reduced in girth, and cortex diminished. " Drumstick " appearance of long bones. Coxa vara, increased convexity of sacrum, sclerosis, and triradiate pelvis, etc.	Low (5 to 8 mg. per 100 c.cm.), but rises on giving vitamin D and calcium.	Usually low (2 to 4 mg. per 100 c.cm.)	High, but diminishes on giving vitamin D and calcium.	Usually high calcium excretion.	Often associated with pregnancy or history of famine conditions.
Healed rickets with deformity.	Bones deformed, but otherwise normal.	Normal.	Normal.	Normal.	Calcium and phosphorus excretion normal.	History of deformity in childhood or adolescence.

The attached table is of value in diagnosing between doubtful cases of metabolic bone disorders in adults, and emphasises the necessity of working with a skilled biochemist in all bone disorders of this type, in many of which, osteitis deformans, fragilites ossium, etc., the ætiology is still obscure in spite of the work of Struthers, Hunter, Mellanby, and many others.

ADOLESCENT RICKETS

This is a somewhat similar disease to the above, met with in a sporadic form about the age of puberty in both sexes, and never resembling the severe type met with in famines. The patients are often overgrown and weedy, but may be of the Frölich type, the onset of the flabby fatness often being of recent date.

The bone changes are similar to those seen in early rickets, there being some decalcification and proliferation and irregularity at the metaphysis ; deformities are common, especially in this latter region, coxa vara being frequently seen, but no attempt at compensatory hypertrophy occurs.

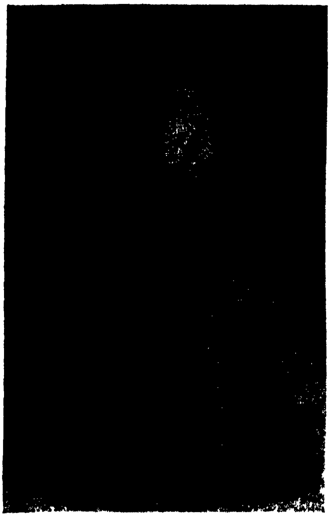


FIG. 286. Adolescent rickets. Epiphyseal appearances similar to Fig. 281.

FIG. 287. Lateral view of the same, showing irregular growth, giving rise to deformity simulating a Colles's fracture.

Clinically there is marked asthenia, sweating, flabbiness and lassitude, with a tendency to pulmonary and intestinal complications. Deformities, due to bones bending and slipping of epiphyses (coxa vara), irregular growth (genu valgum), and yielding of the softened ligaments and tired muscles (adolescent pes planus), are often met with.

Treatment consists in rest, combined with fresh air, good diet, faradism and massage. Deformities, if present, need correction and splintage (Chapter XXI.), and if the patient is of the obese type, thyroid may be of benefit.

RENAL RICKETS

This disease, which is met with in young children and adolescents, possibly can be classed with osteitis fibrosa, as being due to derangement of functional activity of the kidney, rather than to deficiency in diet, and has no relation to true rickets. The chief signs are marked dwarfing of the whole skeleton, without any thickening or deformity of the bones, the epiphyses of which show irregular growth analogous to that seen in rickets. Chronic nephritis with arterio-sclerotic changes in the vessels is always present, and, as Parsons has shown, phosphorus excretion is markedly deficient.

Treatment should be directed to the renal disease, as dietetic treatment is of no avail.

FRAGILITAS OSSIUM

Fragilitas ossium is a term which is used to cover any undue tendency of a bone to fracture, and the cases seen under this heading fall into the following classes, in any of which " Pathological " or " Spontaneous Fracture " may occur.

FIG. 288. Osteogenesis imperfecta with many cysts.

(1) **Disuse atrophy,** seen after prolonged splinting or in paralysed limbs, where absorption of the compact bone may occur to a great extent and fracture may be caused therefore by very slight violence.

(2) **Neuropathic atrophy** occurs in many nervous diseases, notably general paralysis of the insane, tabes and syringomyelia, and to a lesser extent in hemiplegia, paraplegia and infantile paralysis, where it is associated with disuse atrophy. The importance of remembering the undue liability to fracture in cases of general paralysis of the insane always must be borne in mind in dealing with questions relating to alleged violence from attendants in restraining these patients.

(3) **Absorption and replacement of the bone by neoplasms,** especially sarcoma and secondary carcinoma.

(4) **Pressure atrophy,** from extrinsic causes, usually aneurysm but occasionally tumour.

(5) Those cases, not often seen, of **osteogenesis imperfecta,** a condition usually congenital, but sometimes apparently coming on in early infancy, in which there is a great tendency to fracture, as owing to apparently defective osteoblastic activity little compact bone is formed. The bones are shell-like in thickness, and so fractures and consequent deformity are common, many of these occurring in utero or at birth. The fractures usually unite normally.

There appears to be a hereditary influence, and there may be several cases in a family; the children may be stillborn or often die in infancy, but if they survive they appear to grow out of the condition about puberty.

Clinically nothing abnormal will be noted unless deformities from previous fractures are obvious. Fractures occur from the most trivial violence or even normal muscle action. The sclerotics are noticeably blue-white on examination.

Treatment consists in gentle handling and careful splinting. Endocrine extracts and gland grafting have been tried with but poor success.

OSTEITIS FIBROSA

This disease, sometimes known as " fibrocystic disease " of bone, would appear to be closely allied to myeloma (osteoclastoma) of bone, with which it may be associated, so that some authorities regard it as an early stage of the tumour formation. The disease is characterised by the absorption of the medulla and cancellous bone and its replacement by vascular granulation or connective tissue, in which hæmorrhages frequently occur, resulting in cyst formation when the clot organises and absorbs.

The condition usually occurs in adolescents at or soon after puberty.

Clinically two types of the disease occur :—

(*a*) The common localised variety usually met with in the long bones, the femur being a favourite site, in which a single cyst is detected in the bone, perhaps as the result of pain or spontaneous fracture through the thinned osteum (**solitary bone cyst**), in which case union is usually good and satisfactory. An X-ray film reveals the condition as an oval clear area in the centre of a patch of expanded and rarefied bone ; there is no sclerosis round it.

In this single or localised form there is usually no parathyroid abnormality.

Treatment consists in exploration and excision or free curettage of the cyst and softened area. Bone-grafting may be resorted to to fill the gap. Pathological fracture, which is common in these cases, needs splinting only, for good union occurs as in a normal bone. Subsequently the bone appears normal and seldom shows further signs of disease.

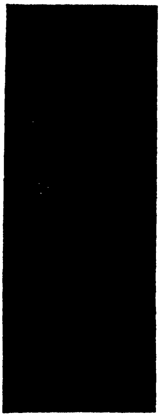


Fig. 289. Solitary cyst in the shaft of the humerus with pathological fracture.

Diagnosis from myeloma (osteoclastoma) is almost impossible, even with X-ray examination, unless trabeculæ can be detected crossing the cavity, when the diagnosis of myeloma can be made, though occasionally such trabeculæ are met with in osteitis fibrosa. Central sarcoma, hydatid cyst, or more rarely central fibroma, may also give rise to difficulty in diagnosis. From Brodie's abscess the condition can be distinguished easily by the absence of the surrounding osteoperiostitis so characteristically seen in X-ray photographs of the localised bone abscess.

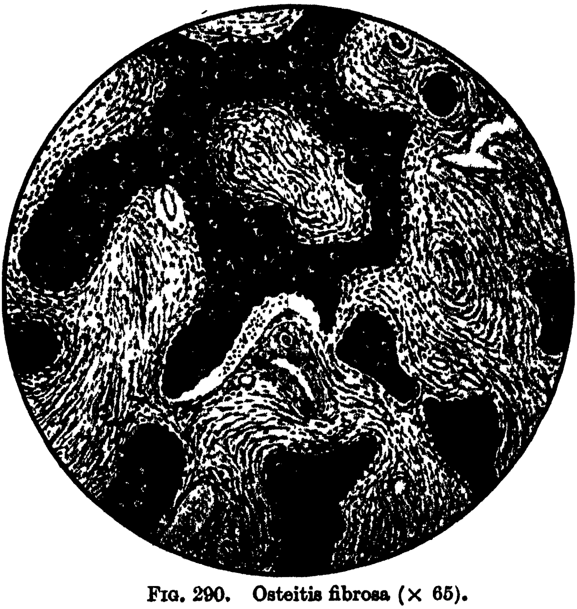


Fig. 290. Osteitis fibrosa (× 65).

(*b*) The rare diffuse or generalised osteitis fibrosa is uncommon; it affects all the bones, including the jaw and skull. Spontaneous fractures are common as in the localised type, and blindness and deafness may supervene from pressure of the thickened bones on the second and eighth nerves respectively; palsy of the facial nerve has been noted. Both the blood calcium and that excreted in the urine are greatly in excess of normal.

The disease is slowly progressive and medical treatment is unavailing, though it apparently may be temporarily ameliorated by the administration of thyroid or adrenalin.

This diffuse form has been shown to be due definitely to the influence of the parathyroid glands. In most instances a definite parathyroid swelling has been present, which is usually an adenoma and occasionally a simple hyperplasia. Removal of the swelling usually cures the condition. In some cases, though no parathyroid swelling has been palpable, exploration of the neck has revealed one often behind the sternum. (See Vol. II., Chapter II.)

The condition closely resembles diffuse "myelomatosis" (Chapter VIII., p. 214), save that it occurs in younger persons; Bence-Jones albumose may be present in both conditions.

BONE AFFECTIONS IN SCURVY

Scurvy is a nutritional disorder due to absence of vitamins from lack of green vegetables and fruit in the diet and is characterised by the presence of hæmorrhages in the tissues, spongy, bleeding gums, asthenia, general muscular weakness with a tendency to cardiac failure, and transient œdema of toxic origin. Hæmorrhage into the soft tissues has been discussed already (Chapter IV., p. 57), and at this place only the bone affections need be considered.

Infantile scurvy is met with in babies, usually the children of well-to-do parents, as the results of bad feeding, generally with patent foods of unsuitable composition. The child presents all the signs of scurvy in a varying degree and is fretful and irritable, the gums are spongy and melæna may be present. *Subperiosteal hæmorrhages* are by no means uncommon and result in the formation of painful, tender swellings on the bones, usually near their extremities; later these become organised and a subperiosteal fibrous thickening results, which on superficial examination may be mistaken for rickets and give rise to the misleading name of scurvy-rickets in this condition. Intramedullary hæmorrhages may occur also, occasioning severe pain, and causing the limb to be held motionless and giving rise to a pseudoparalysis; if large the hæmorrhage bursts out along the shaft side of the epiphyseal cartilage and causes a subperiosteal fusiform swelling which, in its turn, may extravasate among the muscles; in many of these cases separation of the epiphysis results, with its attendant disability, or a hæmarthosis may occur (Chapter XIX., p. 587).

Treatment is directed to giving suitable diet, with fruit juice. Pressure and splintage will be necessary in cases where joint or epiphyseal damage has occurred.

Adult scurvy results from prolonged deprivation of green vegetables; it used to occur in ships, and was seen extensively among the troops in the Balkans during the late war. In the osseous system both intramedullary and subperiosteal hæmorrhages may occur, the former causing great pain of a boring character, worse on using the affected bone, and the latter often giving rise to a very considerable fusiform swelling around the bone.

X-rays film show no change in the bone or periosteum, though this latter may be seen separated from the underlying osteum.

Treatment consists in rest and pressure; massage is to be avoided, as it tends to increase the hæmorrhage, and on no account should aspiration be permitted; after a few days, gentle use of the affected limb should be allowed, with the object of promoting absorption of the effused blood. General hygiene and diet should be attended to.

The *diagnosis* in both types of the disease is between scurvy and other blood conditions in which similar hæmorrhages may occur, but the spongy, bleeding gums and asthenia usually will render the cause obvious in scorbutic cases; sarcoma is another source of error. Of the blood diseases, hæmophilia is the most likely to cause trouble (Chapter IV., p. 57), and here the family history and healthy aspect of the patient, a male, will usually establish the diagnosis. Severe myelogenous leukæmia, secondary anæmia, and pernicious anæmia may all give rise to hæmorrhages, though usually these are small and subperiosteal only. Toxæmias in severe septicæmia and hæmorrhagic fevers (smallpox, scarlet fever and measles) may all be accompanied by subperiosteal or intramedullary hæmorrhage, and separation of epiphyses may occur in these diseases, as also in severe purpura (purpura fulminans).

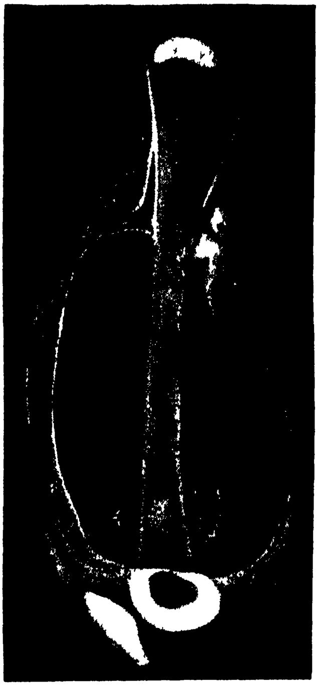


FIG. 291. Subperiosteal hæmorrhage in a case of infantile scurvy, showing separation of the lower femoral epiphysis.

FIG. 292. Subperiosteal hæmorrhage of the tibia in a case of malignant scarlet fever, showing stripping of the periosteum.

The diagnosis from sarcoma may be very difficult, not only on physical signs, but also on exploration if the tumour is very vascular, but X-ray examination will clear up the difficulty at once; for in scurvy the bone outline is clear-cut and the density normal, whereas in sarcoma there is always some slight blurring of outline due to deposit of subperiosteal bone, and some alteration in density, usually rarefaction, where the neoplasm has replaced bone.

SKELETAL LIPOID GRANULOMATOSIS (Hand-Schiller-Christian's disease)

This is a rare condition in which usually in children deposits occur in the membranous bones closely resembling malignant tumours but which are probably produced by a stimulus of the so-called reticulo-endothelial tissues by a chemical lipoid, resulting in what may be called a lipoid granulomatosis.

These granulomatous masses are firm, putty-like and seen in the dura, the diploë, the base of the skull, clavicle, pelvic bones, lungs and liver. The disease is seen in poorly developed children who, in addition to the osseous deposits in the skull, have exophthalmos and diabetes insipidus. They are cross and irritable, cry a lot and are mentally upset, possibly as the result of increased intracranial tension. The scalp veins are dilated. Diabetes insipidus appears later with polydypsia and polyurea, probably due to hypothalamic irritation, while the exophthalmos is probably caused by pressure from granulation tissue extending into the orbits. The calvarial osseous swellings and defects are marked. Jaundice or pulmonary changes may occur The prognosis is not good.

Treatment. A cholesterol free diet should be given with an abundance of green vegetables. Insulin and pituitary extract are helpful. Deep X-ray treatment is of the greatest benefit.

TUMOURS OF BONE

Neoplasms occurring in relation to bone and cartilage have already been discussed (Chapter VIII.), and the reader is advised to refer to the description

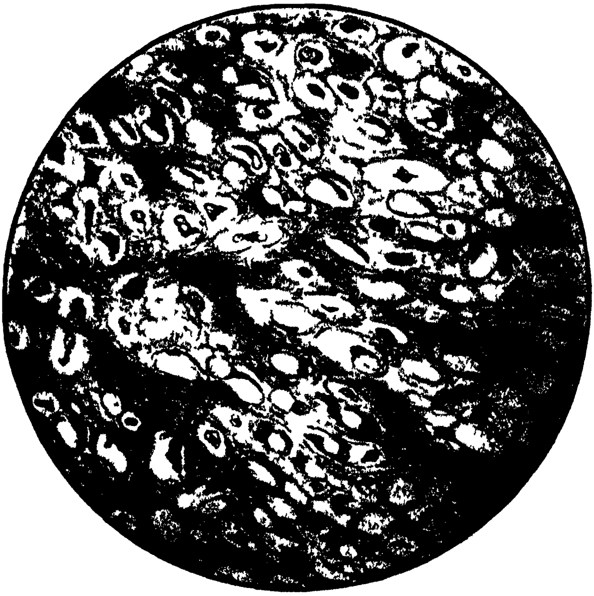


FIG. 293. Chondroma of finger (× 200).

there given; it may, however, be useful to remind him that all primary tumours of bone, simple and malignant, will be of connective tissue origin, but that metastases may occur in bone secondary to malignant growths of either connective tissue or epithelial origin elsewhere in the body.

(A) *Primary Tumours.*

1. *Simple Connective tissue neoplasms* of any type may occur in relation to the osseous system, but many are of such rarity as scarcely to merit notice, such as angiomata, whereas others are of fairly common occurrence, as chondromata and osteomata.

(*a*) **Chondromata** (Chapter VIII., p 200) have been already fully dealt with, and here it will suffice to notice that such neoplasms are usually met with in connection with (i.) the short bones of the hand and are then frequently multiple, but (ii.) they may occur as a single large lobulated mass arising from any bone, in which case they frequently follow trauma; though such tumours may remain simple for a long period, as evidenced by the normal outline of the bone contiguous to the growth, they usually ultimately undergo sarcomatous changes. In all chondromata there is a marked tendency to a degenerative calcification, and often definite ossification occurs, when, of course, a shadow will show in an X-ray film in the otherwise clear area occupied by the chondroma.

FIG. 294. Osteoma of the tibia.

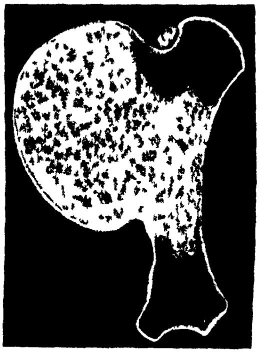


FIG 295. Cancellous osteoma of a metacarpal.

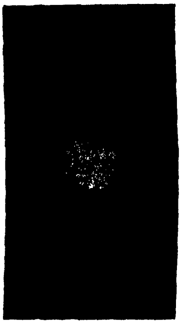


FIG. 296 Cancellous osteoma.

The *diagnosis* is from callus due to fractures, and from sarcoma or osteoma, and is easily established by X-ray films (Chapter VIII., p. 202). Ecchondroses arising from the margins of the articular cartilages in degenerative joint changes in osteoarthritis and Charcot's disease should not give rise to any trouble in diagnosis (Chapter XIX.). It will be realised, of course, that no chondroma ever arises in connection with a membrane bone.

(*b*) **Osteomata** have been discussed on p. 203, and it will be remembered that two varieties occur:—

(i.) The commoner *cancellous type*, near the ends of long bones, especially in rachitic subjects, which are capped with cartilage, often surmounted by a bursa, and may be multiple. They cease to grow when the bone does, and are easily removed.

Diaphysial Aclasia. This name is sometimes given to certain cases of multiple osteomata, which, although they are apparently tumours, are more probably a congenital irregularity of bone growth, perhaps due to endocrine influence. The condition often appears to be hereditary (60 per cent. of cases). The swellings are found at the ends of the long bones, and are often symmetrical; they are painless and grow slowly during childhood. Growth ceases at maturity, and the swellings only cause symptoms if by any chance they press on important structures. In some instances the long bones are stunted or even bent, so that the condition may resemble rickets. No treatment is usually required, though any particular swelling is easily removed.

(ii.) *Ivory osteomata* are met with occasionally in the membrane bones of the skull, are hard and difficult of removal, and if growing internally may give rise to cerebral symptoms. One variety met with in the external auditory meatus may cause vertigo and deafness, and needs removal with a gouge or burr.

The *diagnosis* of the ivory osteoma from leontiasis ossium, a condition of chronic septic osteoperiostitis arising in the maxillæ and frontal bones from chronic suppuration in the air sinuses, can be established easily by examination of these sinuses.

(*c*) **Lipomata** (Chapter VIII., p. 193) may occur deep to the periosteum, when they cause circumscribed semifluctuant swellings, usually mistaken for chronic abscesses due to peripheral tuberculous osteitis.

(*d*) **Fibromata** (Chapter VIII., p. 195) are rarely seen, and may be met with either subperiosteally, or very occasionally as central neoplasms in the medullary canal; they are usually soft and often become sarcomatous. The diagnosis is from sarcoma, which can be determined on X-ray examination by noting that in the simple tumour the bone outline contiguous to it is normal and clear-cut, though, of course, expanded in the case of a central fibroma.

The *treatment* consists in excision of the tumour in the subperiosteal growths, as with lipomata; in the central fibroma resection with the surrounding bone is advisable (when the neoplasm will be found to be free of the inner wall of the compact bone), with a bone graft to bridge the gap thus caused.

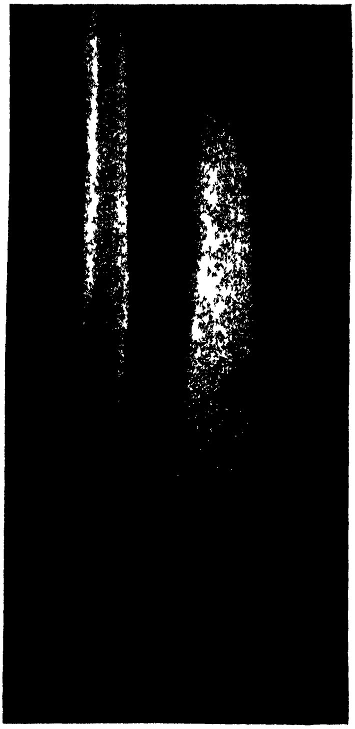


FIG. 297. Periosteal sarcoma of the radius, with radiating spicules of new bone.

(*e*) **Angiomata and Neurofibromata** have been reported in connection with the medulla, but are so rare as only to merit passing mention.

(*f*) **Myxomata** may occur rarely, but many so-called myxomata are œdematous masses of granulation tissue arising in connection with carious bone around infected sinuses near mucous cavities. Thus *nasal* and *aural polypi* (Chapter VII., Vol. II.) are granulomatous masses of this nature; they always need radical operations on the sinuses with removal of the diseased bone to effect a permanent cure, and not merely avulsion of the polypoid mass, which, of course, will recur unless the carious bone is dealt with.

2. *Malignant neoplasms of the connective tissue type* may occur as either :—

(*a*) **Osteoclastoma** (Myeloma) is a locally malignant tumour arising in connection with the osteoclasts, usually at the ends of long bones, and described in Chapter VIII., p 212 ; the fuller consideration of the diagnosis of this type of growth is dealt with under Central Sarcoma.

(*b*) **Sarcoma,** which may be of any of the varieties described in Chapter VIII., p. 215, but is most frequently of the spindle-celled type.

Clinically two forms are met with :—

(i.) Peripheral or Subperiosteal (Osteogenetic) (Plate VII.).

(ii.) Central or Endosteal (Ewing's tumour) (Plate VIII.).

(i.) **A Peripheral or Subperiosteal Sarcoma** (osteogenic sarcoma) is usually of the spindle-celled variety, and occurs as a compact, vascular, fleshy mass arising from the deeper layers of the periosteum, which is stripped from the underlying bone by the growth of the neoplasm, which occurs far more rapidly along and around the bone than into its substance ; as already pointed out (Chapter XVIII., p. 528), the stripping away of the periosteum results in avulsion of osteoblasts around the blood vessels from the Haversian canals, with consequent appearance of new bone, usually in the form of radiating spicules, in the substance of the growth.

Such tumours usually occur towards the extremity of the shaft of a long bone, or grow from the surface of a short or flat bone near the epiphyseal line, frequently following on some slight trauma ; the onset is insidious, a soft mass appearing on one aspect of the affected bone, spreading rapidly and extending up and around the shaft in the case of long bones.

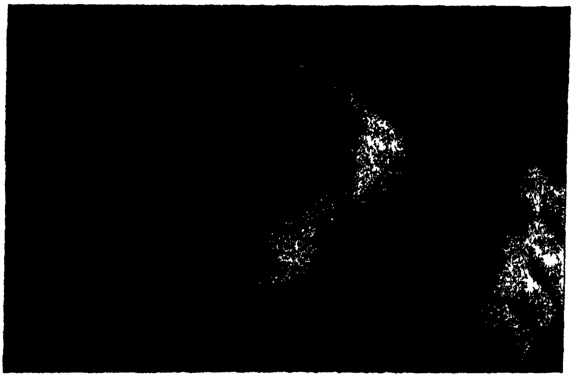


FIG. 298. Sarcoma of lower end of radius.

Pulsation may be present or a bruit be detected, and in large tumours venous engorgement over and distal to the mass is frequently seen as the result of obstruction to the blood return, for which reason the skin is often dusky and the temperature raised.

Pain may be an early symptom, but is usually not marked until the neoplasm has broken through the periosteum and involved neighbouring nerves. The growth may be accompanied by some effusion, often bloodstained, into the neighbouring joint, which later becomes invaded and disorganised by the sarcoma; as also will be the muscles and skin in the neighbourhood if treatment is neglected, in which latter case a sloughing, bleeding, sarcomatous ulcer will be present.

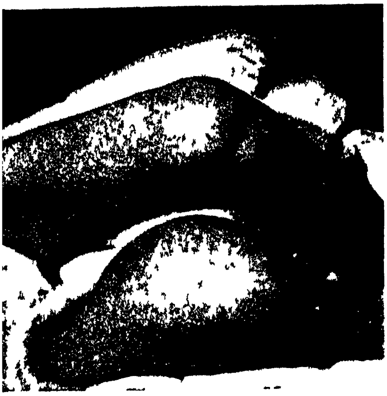


FIG. 299. Sarcoma of the lower end of the right femur.

It is worthy of note that the avascular articular, and, in adolescents and children, epiphyseal cartilage escapes invasion, and persists practically intact in the midst of a mass of growth, while even in late cases, where the medulla is invaded, the original outline of the compact bone of the shaft can be usually detected on section of the tumour.

Firm pressure over the tumour may elicit fine crepitus from crushing of bony spicules, but true "egg-shell crackling" is seldom elicited in subperiosteal sarcomata.

The temperature is usually slightly raised (99° F.) at night, but there is no sweating.

X-ray examination reveals a diffuse mass around, and in late cases in the bone, but always with more extension outside the bone than inside; radiating spicules of an osseous nature are seen, and the bone may be partially destroyed and rarefied, being replaced by the neoplasm, so that "spontaneous fracture" (p. 406) may occur; and indeed this is not infrequently the first sign of a tumour, so that careful examination, both physical and radiological, should be carried out in all cases of fracture resulting from slight violence, with this in view.

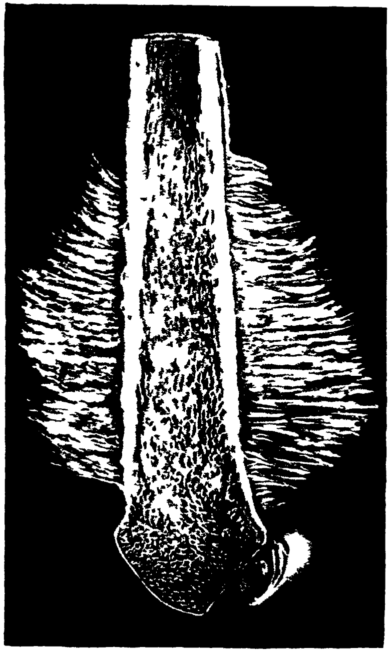
It should be noted carefully that the outline of the bone contiguous to the neoplasm is blurred and roughened, due to invasion of the compact bone and new bone formation on its surface.

The *diagnosis* is mainly from gummatous osteoperiostitis of the hypertrophic type, and also from periosteal nodes; but in both these conditions there is usually more swelling on one aspect of the bone than the other; in either case the uniform hardness of the osseous inflammatory tissue, its dense opacity on X-ray examination, and a positive Wassermann reaction will clear up the difficulty.

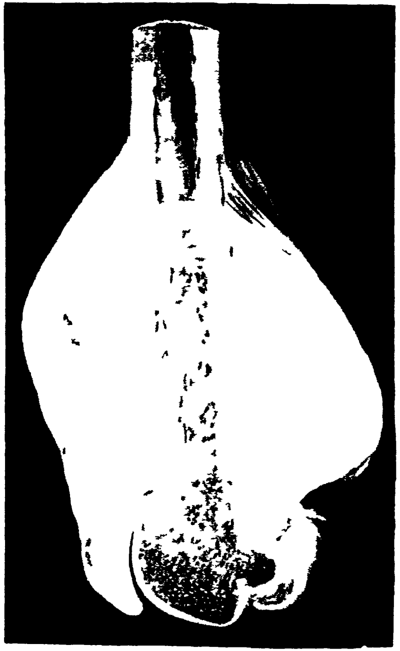
From subperiosteal hæmorrhage in scurvy or hæmophilia it is often impossible to differentiate on local clinical examination; but the X-ray film at once establishes a diagnosis, the bone in both scurvy and hæmophilia being normal in appearance, and presenting a smooth, sharply defined outline, though in infants it may show the displacement of a separated epiphysis (p. 411), whereas, in sarcoma, considerable fluffiness of outline is present. In both blood diseases signs will be present elsewhere in the body, and there will be a family or dietetic history which will be helpful.

Diagnosis from Brodie's abscess, tuberculous, septic or gummatous, may present many difficulties from a clinical standpoint, but is at once clear in X-ray films. Clinically, however, the greater prominence of the swelling on

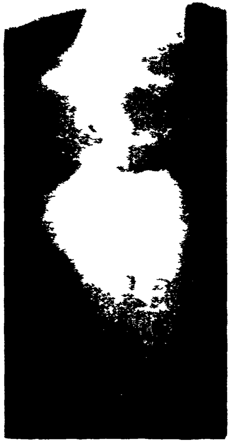
PLATE VII.



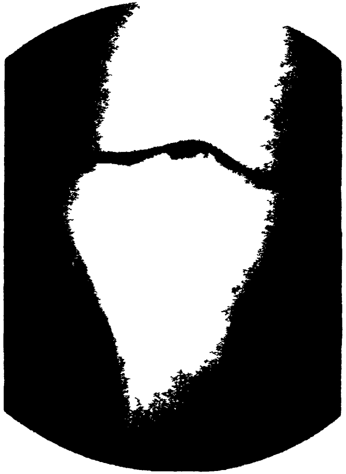
A Dried bone from Fig B, showing radiating spicules of new bone in the sarcoma.



B Periosteal sarcoma of lower end of the femur Note intact articular cartilage



C Periosteal new bone laid down in periosteal sarcoma



D A similar condition (*C and D X ray films*)

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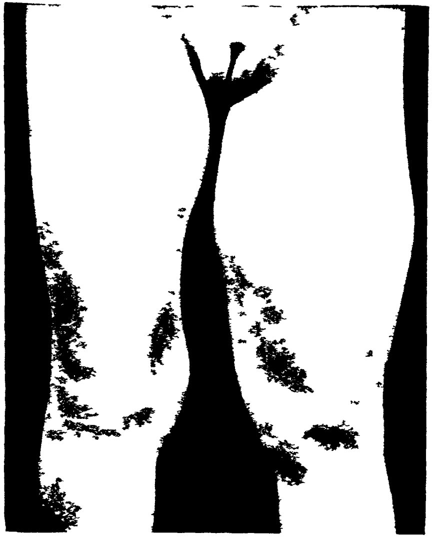
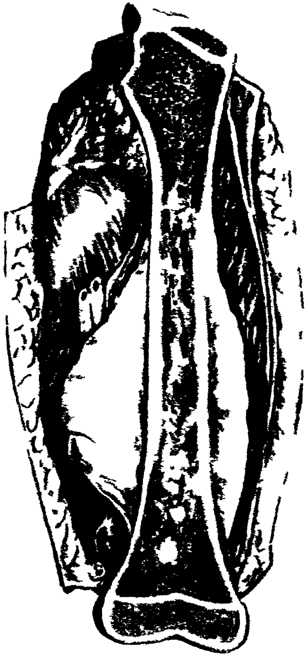
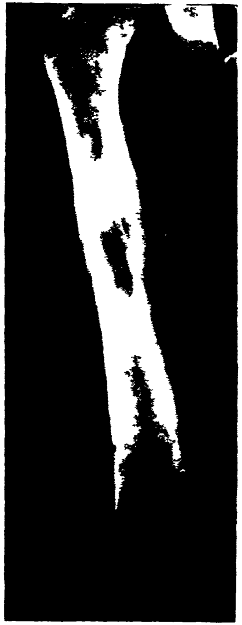
PLATE VIII.



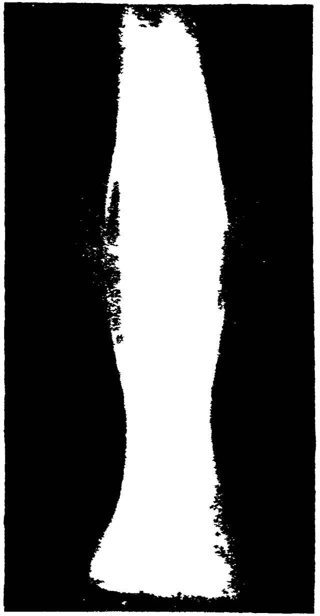
A Sarcoma of the middle of the shaft of the femur (L.)



B The same periosteal sarcoma of femur arising at the middle of the shaft



C X-ray film of the same showing appearances of septic osteitis so characteristically seen in sarcoma originating in the middle of the shaft of a long bone



D Sarcoma of the middle of the femoral shaft one side, and its soft nature and vascularity are usually sufficient to establish a diagnosis of subperiosteal sarcoma.

Very rarely a subsynovial sarcoma may give rise to considerable difficulty in diagnosis. Such conditions as syphilitic osteoperiostitis, osteoarthritis, Charcot's disease, and myositis ossificans can be at once diagnosed on X-raying them, even if any clinical doubt exists. The presence of synovial effusion may lead the tyro to diagnose tuberculous or rheumatic synovitis, the primary cause of the fluid escaping notice.

It should be noted that a variety of periosteal sarcoma is occasionally met with, usually at the middle of the shaft of a long bone, in which the new bone formation of the neoplasm is in the form of an irregular dense mass, closely resembling in appearance, both naked eye and on X-ray examination, that seen in myositis ossificans traumatica (Chapter XIII., p. 388); from this, however, the sarcoma can be diagnosed at once by a careful observation of the surface of the bone immediately contiguous to the tumour; for in both the X-ray film and the fresh and dried specimens the surface of the shaft will be seen to be roughened by new bone formation and eroded by the invasion of the tumour in the sarcoma, whereas it is smooth and normal in appearance right up to the limit of attachment of the osseous mass in myositis ossificans. The diagnosis between these conditions is of the utmost importance, for although this variety of subperiosteal sarcoma is fortunately rare, the most tragic disasters are not unknown consequent upon its treatment by expectant means under the misapprehension that the condition is myositis ossificans traumatica.

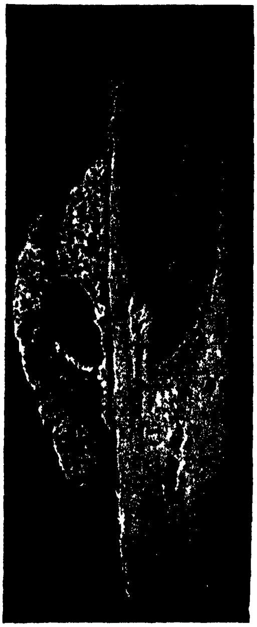


FIG. 300. Sarcoma of the middle of the shaft of the femur. Note the roughening of the bone surface and obliteration of the medulla.

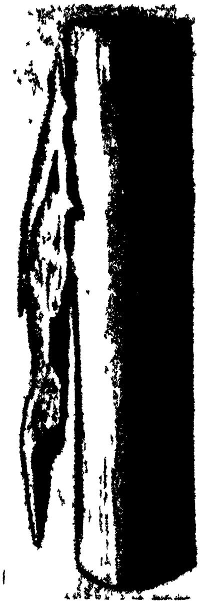


FIG 301 Myositis ossificans traumatica. Note the smooth femoral surface up to the lesion.

Treatment is not satisfactory, and no drastic local treatment should ever be attempted until X-ray films of the other parts of the body, especially the lungs, have shown that no metastases are present. Amputation of the affected limb is usually carried out, but inasmuch as death often results in a few months from metastases, it is, in the opinion of many surgeons, not justifiable to perform so drastic an operation unless there is pain, ulceration, or disorganisation of the limb. In such a case radium may be implanted (Chapter XXIII), deep X-ray therapy applied (when the local condition often improves, but metastases frequently appear), or local removal may be attempted, where this will not disorganise the limb, *i.e.*, as in the lower extremity; in other cases one of the less severe amputations may be carried out.

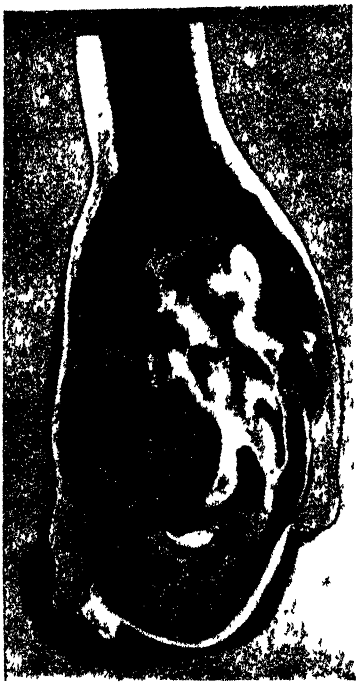


FIG. 302. Endosteal sarcoma of the lower end of the femur.

The *prognosis* is very bad, death usually occurring in from three to six months from the onset of the disease, which is more rapid in progress in children than in adults.

(ii.) **Central or Endosteal Sarcoma** is usually of the round-celled type, and not uncommonly differentiated multinucleate giant cells may occur, giving rise to great difficulty in diagnosis from myeloma (osteoclastoma), even under the microscope, though here the tumour is usually round as against the ovoid mass in sarcoma ; in such cases, however, the clinical history is short and metastases appear rapidly, thus distinguishing the condition from myeloma, which is only locally malignant.

Clinically there may be a history of injury, but often the onset is insidious, the patient's attention being attracted by the slight, persistent pain, a chronic synovial effusion or even a spontaneous fracture.

On local examination the affected bone, usually toward one extremity of a long bone, is found to be uniformly expanded, a fusiform enlargement presenting itself; this is hard and bony in the early stages, but later, as the bone becomes destroyed, the neoplasm breaks through, and one or more soft spots may be detected in the swelling, over which areas pulsation or a bruit may be present; where the bone is very thinned " egg-shell crackling," due to fracture under the examining hand, may be elicited.

An effusion of a serous nature is often to be detected in the neighbouring joint. In the later stages the tumour, having escaped from its casing of periosteal new bone, invades the surrounding tissues, where it can be felt as a soft mass. Pain, vascular engorgement and disorganisation of the limb result, though at a later date than in the case of subperiosteal sarcomata. The patient shows little general signs in the early stages, though the temperature is usually slightly raised (99° F.) at night. An X-ray film reveals a fuiiform expansion of the bone in the affected area, with slight osteoperiostitis of the contiguous surface of the shaft and consequent blurring of the outline, and considerable thinning of the compact bone in this area, the inner surface being irregular. The medullary space is occupied by a rarefied area, where the cancellous bone is destroyed, and it often shows a mottled appearance due to hæmorrhages into the growth, which is roughly spherical in outline; the canal on both sides of this area usually contains some new bone, and its shadow is thus denser than normal, which is the more marked in contrast to the rarefied area occupied by the sarcoma.

There is one type of endosteal sarcoma (Ewing's tumour) which gives rise to an X-ray appearance very suggestive of chronic osteitis, and indeed in some cases diagnosis by X-ray films may be impossible; but as a general rule careful study of the skiagram will show absence of any clear area (Brodie's abscess), or definite sequestrum, and the new bone is thinner and more fluffy than in the case of septic osteoperiostitis (Chapter XVIII., p. 554); still, should any doubt exist, immediate exploration, with, if necessary, microscopic examination of the removed tissue, will clear up the diagnosis, and this is urgently indicated.

In all cases the lungs should be X-rayed, as metastases are frequent and occur early, probably because the veins in the Haversian canals are held patent by their attachment to the osseous walls.

The *diagnosis* may present many difficulties and is frequently impossible without exploration, an operation which must be undertaken at once and unhesitatingly in doubtful cases. Perhaps the most frequent difficulty is met with in the cases of *localised septic osteitis* (Brodie's abscess) (p. 542); but here the small, smooth-walled cavity with no mottling, and the uniform density of the surrounding bone in an X-ray film, usually clear up the diagnosis, and clinically the signs of old sepsis or the detection of similar lesions elsewhere go far to help. In both diseases a nocturnal temperature may be present; the detection of pulmonary or other metastases is conclusive.

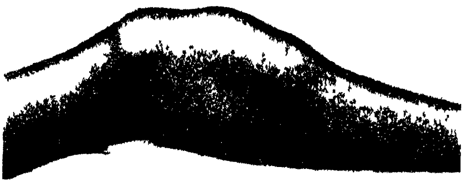


FIG. 303. Osteoclastoma (myeloma) of the upper end of the tibia.

Another fruitful source of trouble is a *solitary bone cyst*, probably an early stage of osteitis fibrosa (p. 571), a condition not infrequently associated with sarcoma of bone, and by some authorities regarded as its precursor; in this condition there is also a fusiform swelling, which, however, is usually about the middle of the shaft, the X-ray film showing a single, clear-cut, spherical, rarefied area, usually uniform in appearance, though it may be crossed by one or two trabeculæ, where partition walls exist; the surrounding bone is normal in appearance, or rarefied, and shows no osteoperiostitis. The temperature is not raised at night unless sarcoma or some other disease coexists.

Osteoclastoma (myeloma) (p. 577) is frequently impossible to differentiate, without actual microscopy, as both clinically and on X-ray examination the appearances are identical; sometimes, however, the tumour area in the myeloma presents a more rounded outline, and large, clear areas crossed by trabeculæ, corresponding to the walls of the hæmorrhagic, cystic cavities, and in such cases the appearance is quite conclusive of the more benign neoplasm being present. Endosteal fibromata may occur occasionally, but are more likely to be mistaken for solitary cysts than sarcomata. Hypertrophic syphilitic or tuberculous osteoperiostitis may give rise to difficulty until an X-ray film reveals the generalised sclerosis of the whole bone, including the medullary canal, and similarly osteitis deformans, when occurring in one bone only, may arouse suspicion; it should be remembered that in this last-named condition sarcoma, usually of the subperiosteal type, frequently supervenes, but only in the later and general stage of the disease.

Lastly, attention must be drawn to the frequency with which errors in diagnosis between an endosteal sarcoma and secondary deposits of carcinoma, or hypernephroma, lead to the useless sacrifice of a limb, through failure to detect the primary tumour (pp. 190, 191).

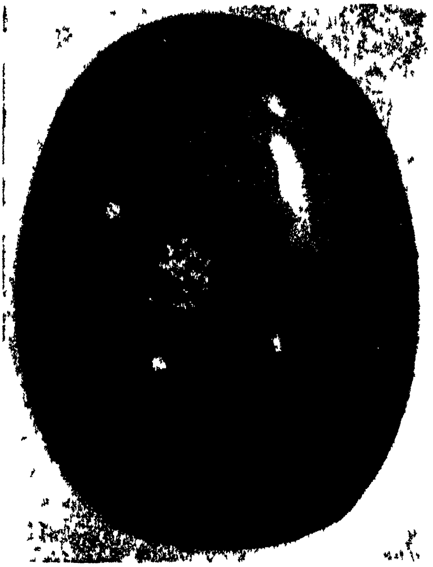


FIG. 304. Secondary carcinomata in the skull.

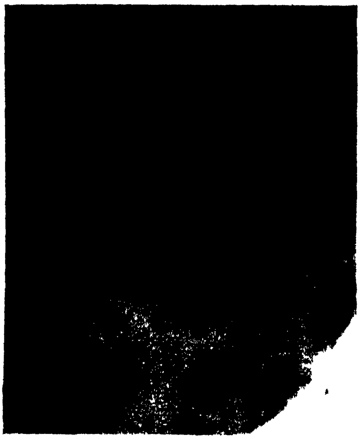


FIG. 305. Secondary carcinoma of the sk
in a case of carcinoma of the brea
Note the absence of new bone formatio

The prognosis is always serious, though perhaps rather less so than in subperiosteal tumours.

Treatment is on the same lines as that indicated in the case of subperiosteal growths, local removal with the curette and diathermy being nearly always followed by early recurrence in the case of sarcoma; they may be successful in myeloma, provided a useful limb can be obtained after local removal.

Radium and X-rays tend to cause rapid disappearance of these endosteal growths in most cases, but they recur soon and metastases are frequent.

(B) *Secondary tumours* are met with in bone secondary to carcinoma, usually spheroidal-celled in type, and particularly when the primary growth is situated in the thyroid, breast or prostate (Chapter VIII., p. 184), in which latter position it is particularly liable to escape detection, even if a thorough examination be made; occasionally columnar-celled (uterus and bowel) or squamous-celled (tongue and lip) carcinoma may give rise to extensive and widespread bone metastases.

Clinically three types of metastases are met with, which are dealt with in their order of frequency :—

(*a*) *Localised metastases* occurring near the growth, or in the proximal ends of the limb bones, usually lymph-borne, but sometimes undoubtedly blood-borne, and occurring in the distal bones of the extremities; in this type the patient usually experiences no disability till a spontaneous fracture occurs, as the bone destruction and its replacement by carcinoma is gradual, and absolutely no bone reaction occurs. An X-ray film, therefore, reveals rarefaction due to caries without any signs of osteoperiostitis. Following fracture, the bone reaction usually develops, union occurs normally, and all local evidence of the tumour may be destroyed, the bone appearing normal on X-ray examination; subsequent metastases frequently occur, while others may be present elsewhere. This type of metastasis is commoner with carcinoma of the breast and thyroid, and has to be diagnosed from tuberculous caries or chronic superficial osteitis with subperiosteal abscess formation ; in the former case the X-ray film shows no osteoperiostitis, and in the latter there is again no new bone formation, and should the tumour be incised it will be found semi-solid and to contain no pus ; this operation, however, should be avoided if possible by a careful search for the primary neoplasm, the finding of which will establish the diagnosis. Such fluctuant swellings are particularly common in connection with the flat bones of the cranial vault, and if arising

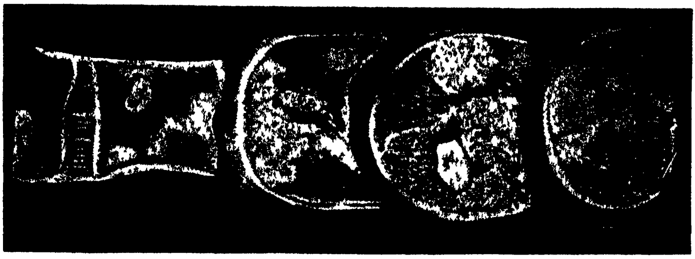


FIG. 306. Secondary deposits of carcinoma in the vertebræ in a case of scirrhus mammæ.

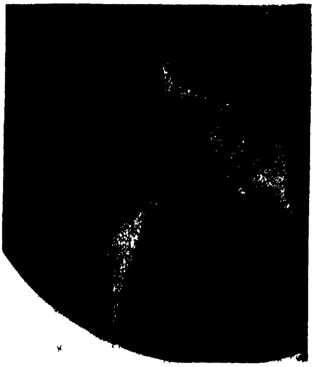


FIG. 307. Destruction of the upper part of the head and neck of the femur by a carcinomatous metastasis.

secondary to adenocarcinoma of the thyroid may pulsate or even give rise to active thyroid secretion (Chapter VIII., p. 181).

(*b*) *Localised tumours* occur usually in the bones of the trunk or limb girdles, with the formation of a dense ensheathing layer of osteoperiosteal new bone, thus resembling clinically and on X-ray examination central sarcoma, or less frequently the spina ventosa type of tuberculous osteitis; from this they can be diagnosed only by the discovery of the primary carcinoma, which, as this type of metastasis is frequently secondary to neoplasm in the prostate, easily may escape detection, and the secondary bone tumour be mistaken for a primary endosteal sarcoma (p. 580).

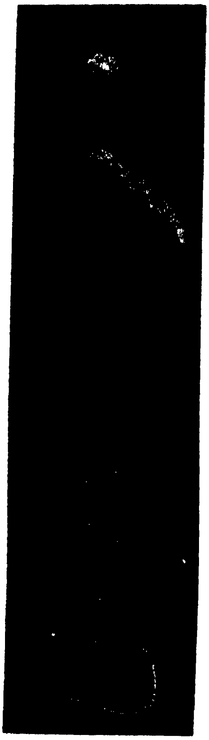


FIG. 308. A femur diffusely infiltrated with secondary carcinoma, showing bone absorption, without new bone formation and consequent bending.

(*c*) Rarely a *diffuse infiltration of several bones* may occur, the osseous tissue being replaced by the carcinoma, with no formation of new bone; hence, though the osseous skeleton keeps its normal size, the bones bend in all directions and spontaneous fractures, usually greenstick, may occur, the patient becoming bedridden from inability of the skeleton to afford support. An X-ray film shows generalised rarefaction affecting mainly the long bones near the trunk, and the condition may thus often be confused with osteomalacia, which it otherwise closely resembles, if the primary carcinoma, usually in the breast or prostate, escapes notice.

The prognosis is, of course, hopeless.

Treatment consists in alleviating local symptoms; splinting, and not amputation, should be resorted to in spontaneous fracture, as union nearly always occurs; hence the importance of diagnosis from sarcoma. Deep ray therapy would seem to be of some use in these cases.

Hypernephroma occasionally causes metastases in bone, often in the ulna, where a diffuse fusiform swelling usually gives rise to the diagnosis of endosteal sarcoma or spina ventosa, unless care is taken to examine the abdomen for the presence of a renal tumour and the urine for blood, or a history of previous hæmaturia can be obtained. The bone tumour may pulsate. Little or no treatment can be carried out in these cases, but occasionally removal of the primary neoplasm, with excision of the affected area of bone and its replacement by a bone graft, may be justifiable (Chapter XIV., p. 431).

CYSTS OF BONE

These have already been discussed, and may be multiple and parasitic in origin (see hydatids, p. 137), or single, when they are nearly always associated with osteitis fibrosa (p. 570). In both cases spontaneous fracture is liable to occur and may be the first sign of local trouble.

Treatment has been discussed under the various diseases, and the reader is referred to them as above.

CHAPTER XIX

DISEASES OF THE JOINTS

Surgical Anatomy. Before proceeding to a consideration of the various diseases which may affect the joints, it is necessary to consider briefly the anatomy and physiology of these structures, especially in so far as they affect the various pathological phenomena usually observed.

A joint may be considered as a potential cavity existing deep to the muscular attachments around the ends of the bones, with the object of permitting movements between them, but in order that these may be limited so as to maintain the stability of the body, the walls of the joints are strengthened by certain strong ligamentous bands which stretch from bone to bone in order to prevent or limit certain movements by their rigidity, an object further attained by the counteraction of the muscles opposing the action of any muscular group which contracts to move the bones composing the joint.

In order to permit the smooth movement of the bone ends upon each other, they are capped over the areas on which contact occurs in their movements with a layer of smooth avascular hyaline cartilage (*Articular Cartilage*): the inner surface of the joint is, moreover, lined (with the exception of the surfaces of the articular cartilage) by a layer of serous membrane (*Synovial Membrane*, see Chapter XV., p. 437), with numerous villi projecting from its inner surface, which give it a velvety appearance, and from the cells of which a clear, glairy fluid is secreted, with the object of lubricating the joint surfaces; this synovial membrane forms a complete lining for the joint capsule and its strengthening ligaments, and is reflected in a sleeve-like process around any tendons or ligaments which project through the joint capsule to secure attachment to the bones within its area. Such "intra-articular" structures, therefore, always are separated from the joint cavity by a covering of synovial membrane, which is also reflected from the inner surface of the capsule over such portions of the bones as lie within it; the membrane terminates at the junction of the bone and articular cartilage, which, as already pointed out, is bare and lies within the synovial cavity.

In many cases pouches of synovial membrane protrude from the main synovial cavity to lie between the adjacent tendons of the muscles working the joints, so as to facilitate smooth movement; in such cases the communication with the joint usually is small and slit-like and generally will become obliterated if any inflammation occurs, with consequent œdema, an important consideration in joint infections; moreover, where excess of fluid has been secreted into the joint cavity under such circumstances, these communicating bursæ will be distended and in some cases may be nipped off by the adjacent tendons between which they project and form movable rounded cysts in the neighbourhood of the joint (*Morant Baker's Cysts*, see p. 611).

The villi on the synovial membrane may become hypertrophied, projecting into the joint as a papilliferous mass (*Lipoma Arborescens*), and may then be of interest to the surgeon as they become pinched by joint movements, or undergo degeneration and calcification, when they may become detached and form one variety of loose body (Chapter XVII., p. 513).

The blood supply of the synovial membrane, as already pointed out (Chapter XVIII., p. 528), is very abundant and mainly derived through the circulus vasculosus, which is situated at the reflections of the synovial membrane from the capsule of the bones; in spite of this fact, however, the synovial membrane is very susceptible and poorly resistant to infection of all description, hence joint diseases are both frequent and of serious prognosis.

The articular cartilage is, of course, avascular, and derives the lymph and serum on which its nutrition depends mainly from the underlying bone, but partly from the synovia. It is thus resistant to infection so long as it is intact, but when it becomes disintegrated, a process which occurs rapidly at the pressure points in the motionless limb resultant on joint inflammation, infection spreads between the underlying bone and the cartilage, which necroses and peels away in patches, forming the white flakes so characteristically seen in acute joint infections.

It is of extreme importance to note the position of the *epiphyseal cartilage* in relation to the capsular attachments and synovial reflections, for if, as in many cases (hip, knee, shoulder and elbow), the epiphyseal line falls within the joint capsule, then, as already discussed (Chapter XVIII., p. 542), pus consequent upon metaphyseal infection will of necessity burst into the joint cavity when it escapes along the upper surface of the epiphyseal cartilage, and the joint will be infected thereby (p. 542); a similar result is to be expected in all cases where bones lie surrounded by synovial cavities, as in the carpus and tarsus, and in those rare cases where infection occurs in the epiphyseal nucleus, which it will be remembered derives its blood supply from the same source as the synovial membrane through the circulus vasculosus (Chapter XVIII., p. 534).

It will thus be understood that *Indirect* or *Secondary Infection* of a joint may occur as the result of a blood stream infection *via* the circulus vasculosus, or, as is more common, secondarily to invasion of the synovial membrane from disease of the underlying bone; apart from this, *Direct* or *Primary Infection* is met with following penetrating wounds involving the joint.

The *nerve supply* of the joints, both of the synovial membrane and articular cartilage, is free and derived from that of the adjacent muscles and tendons, there being numerous fibres both for pain and the joint sense of movement and position; it is frequent to find fibres from the same nerve trunk supplying more than one joint, hence it is not uncommon in disease of one joint to find, especially in children, that pain is referred to a neighbouring sound joint, and unless this fact is borne in mind, the diseased joint may escape both examination and diagnosis, with serious results.

In regard to *movements* in joints it must be realised clearly that any movement is the result of the co-ordinated action, often subconsciously carried out, of the group of muscles producing that particular movement, usually with innervation from the same spinal nerve, and that it is automatically controlled by the unconscious contraction of the opposing group of muscles usually innervated from the same spinal segment to check overaction and limit the movement to the requirements of the particular case, this control, in accustomed motions, being exercised by the spinal centres. This point should be borne in mind in performing tendon transplantations to permit joint movements in paralysis, where little good is to be expected or results from transplanting from opposing groups, whereas fair results follow where collateral muscles are available (Chapter XXI., p. 717).

It will be seen further that the blood supply of the synovial membrane, and circulation of the synovia in the joint cavity, will depend largely on the action of the surrounding muscles; hence in all cases where, as in the absorption of effusions and prevention of adhesions, it is desired to maintain or augment the vascular supply to the joint, it is essential to maintain muscle tone and movements; here lies the value of faradic stimulation, massage, active and passive movements in all such conditions (Chapter XV.), when such physiotherapeutic measures should be resorted to early and thoroughly carried out.

In consequence of the innervation of the joint surfaces being derived from the nerves supplying adjacent muscles, any disease and inflammation in or around the joint will be attended by neuromuscular disturbance in the form firstly of trophic changes which can be early detected by loss of tone and consequent flabbiness of all the muscles around the diseased area, and secondly by a spasm of all these muscles; it follows that the joint will be held rigid, and, as in every joint one or more groups of muscles are stronger than their opponents, it will assume a distorted angulation according to the determining pull of these stronger groups, a position constant for the same joint in various persons, but varying in different joints; a third phenomenon constantly observed in the muscles around a diseased joint is wasting, which is usually more marked in the extensor and abductor groups (Gowers) and is apparently consequent on the impairment of blood supply associated with the reflex spasm above alluded to; certainly it is absent in cases where the posterior nerve roots are divided (Hoffa and Allen).

These three neuromuscular phenomena, *i.e.*, loss of tone, as instanced by flabbiness, spasm and wasting, are early and important signs of joint disease.

INFLAMMATION OF JOINTS

As in any other tissue, so in the structures forming the wall (capsule) of the joint, its inner synovial lining, the articular cartilage and bone, any irritant will produce an inflammatory reaction, which in no way differs in its essential points from that seen elsewhere in the body, but the constitution of the joint somewhat modifies the clinical manifestations.

Thus the articular cartilage, being avascular, shows little or no inflammatory reaction, and is resistant to infection so long as its connection with the underlying bone is unimpaired, but so soon as its nutrition from this source is cut off it necroses and peels off rapidly, being then readily disintegrated by granulation tissue; thus the articular surface appears normal so long as it remains intact, but as soon as infection passes through it, or gains hold between it and the bone, the cartilage peels away as dead white flakes and rapidly disappears, exposing a granulating and carious bony surface; again, at the edges, either the synovial membrane may granulate and invade the cartilage (*pannus*), as in tuberculosis, or the cartilage may extend and grow into the synovial membrane, as in osteoarthritis.

Secondly, the excess of fluid consequent upon the inflammatory reaction and increased blood flow rapidly collects in the joint cavity, which it distends as the absorption does not keep pace with the secretion in inflammation, and thus forms an *effusion*, which can be detected clinically by observing the fulness of the joint capsule and the presence of fluctuation.

The effusion may be (*a*) *Bloodstained*, from the tearing of the vascular synovial membrane and bleeding into the cavity; the condition is then known as a **Hæmarthrus**, and is met with regularly in :—

1. Traumatic effusions, simple or with fracture into the joint.
2. Hæmophilia, scurvy and blood diseases.
3. Sarcoma of bone or synovial membrane involving the joint. } These are
4. Neuropathic joints. } very rare.

(*b*) *Purulent*, from infection with pyogenic organisms, either direct or blood-borne, when the condition is sometimes spoken of as **Empyema of the joint.**

(*c*) *Serous*, from effusion of lymph and serum in chronic infections, neuropathic conditions, loose bodies in the joint, or acute toxic infections, when the terms **Hydrops Articuli, Hydrarthrosis** or **Chronic Serous Synovitis** are applied to the condition.

Clinically an effusion in a joint cavity may be detected by noting the swollen appearance of the synovial cavity, the normal sulci and dimples around the joint being obliterated or even bulging. Further, if, as in the knee, a superficial third bone exists, this can be felt to be riding on the fluid, and can be forced back on to the femur on pressure, a phenomenon known as the "patellar tap," the tap being produced by its contact with the underlying bone, when a sharp click can be heard and felt.

In all joints the distension of the capsule causes discomfort and pain, in order to relieve which the joint is held immobile, and in the position of greatest capacity, usually semiflexion. Bursæ communicating with the joint cavity are frequently distended (Chapter XIII., p. 397), and can be felt among the tendons around the joint. Fluctuation often can be detected.

The *treatment* consists in immobilisation under extension till the exciting cause has subsided, with subsequent massage and movements to promote absorption. Should the effusion be very great, aspiration under anæsthesia may be carried out with all aseptic precautions.

Diagnosis. In chronic cases thickened pulpy synovial membrane may give cause to difficulty, but this can still be felt on firm pressure over any given point, whereas the fluid is displaced.

Clinical features. 1. So long as the infection, of whatever nature it may be, and inflammatory reaction remain localised to the synovial membrane (**Acute Synovitis**), the only signs are:—

(*a*) Swelling due to effusion into the joint.

(*b*) Some consequent pain, for the easement of which the joint is held in the position of greatest capacity, usually semiflexion.

(*c*) Loss of tone, with consequent flabbiness of muscle, and some wasting (p. 586).

(*d*) Some lack of mobility of the joint, which, however, is not marked.

2. As the disease progresses and articular cartilage and bone become involved (**Acute Arthritis**) a sharp change manifests itself:—

(*a*) Great pain results from the movement of the inflamed surfaces, and

(*b*) In consequence the limb is held rigidly fixed.

(*c*) This is ensured by a generalised spasm of all the muscles around the joint, which in consequence assumes a deformed position due to the pull of the strongest group of muscles acting on it (usually flexion).

(*d*) Wasting of the muscles from disuse becomes more marked.

(*e*) "Starting pains" due to involuntary movement of the diseased joint surfaces consequent on relaxation of the muscles, as occurs at the commencement of sleep, cause the patient to awake with a cry and start, and immediately immobilise the joint by renewed spasm.

3. Further progress of the infection, often favoured by the fixity of the joint and pressure on the closely apposed and immobile cartilages, results in destruction of intra- and peri-articular ligaments with consequent disruption of the stability of the joint (disorganisation of the joint):—

(*a*) This becomes dislocated by the pull of the stronger muscle groups, which hold the limb fixed in a deformed position.

(*b*) Marked deformity of a permanent nature results from adhesions causing ankylosis of the joint (p. 589).

Treatment on general principles consists in:—

1. Rest of the inflamed part, the joint being best immobilised by a plaster of Paris splint, accurately fitted and bivalved over the region of the joint.

2. Furthermore, it is essential in all cases to prevent pressure on the articular cartilages, hence muscle spasm must be overcome by suitable extension. This may be applied by means of a weight and pulley combined with support of the limb on a skeleton splint, steady traction, or by fixation during traction under anæsthesia in an accurately moulded plaster of Paris splint.

3. If excessive, or purulent, the inflammatory exudate should be removed; the joint being aspirated under all aseptic precautions.

4. Lastly, in any case where damage to the articular facets is diagnosed or feared, great care must be taken to fix the limb in such a position that it will be of use should ankylosis (p. 589) occur.

5. An important consideration in all these cases is the maintenance of the vascular, synovial and lymphatic circulation in the part, for which reason aspiration should be practised if effusion is tense, and physiotherapeutic measures, massage and movements should be adopted as early as compatible with safety. This will be almost at once in the case of traumatic effusions

where the irritant has ceased to exist, but must be of secondary consideration to rest and destruction of the micro-organisms in cases of bacterial infection ; in the latter cases, any subsequent movements must be very cautiously dealt with for fear of breaking down adhesions, and so lighting up the infection by liberation of encapsuled colonies of micro-organisms (see Ankylosis).

Repair and its Resultant Complications. Consequent upon the synovial membrane inflammation the serous coat becomes replaced by a mass of granulations, which later organise to fibrous tissue, and the fibrin from the effusion in the joint clots and becomes deposited on this surface, thus (*a*) impeding the absorption of the effusion, which is dependent largely on removal by the vessels in the synovial membrane ; (*b*) tending to the formation of adhesions between the granulating surfaces, with obliteration to a greater or less extent of the joint cavity and the subsequent formation of fibrous tissue which will limit or prevent free movement of the bones and muscles forming the joint ; this condition will be much aggravated if the articular cartilage has necrosed, so that the granulating bone surfaces have come in contact and adhere, which they are likely to do, as the rigid muscles hold them motionless and touching ; such a condition is known as **Ankylosis of the Joint.**

There are thus, so far as the utility of the joint is concerned, two complications which normally may be expected in consequence of the processes of repair after inflammation in a joint.

(*a*) Firstly, and less serious of the two, a *persistent effusion* may remain and distend the joint cavity, a condition which, if left, leads to weakening of the ligaments in the capsule and wasting of the muscles around the joint. Once, therefore, the acute stages of any inflammatory reaction are passed, it is essential to promote absorption of effusion by encouraging gentle active movements of the joint or stimulating the muscles by faradism, massage and passive movements, with a view to keeping up the blood supply and incidentally of preventing the formation of adhesions with consequent ankylosis.

(*b*) Secondly, *ankylosis* may result from the formation of adhesions ; these may form either :—

1. In the joint cavity (*True Ankylosis*), which is thereby obliterated, though one or two isolated loculi may persist. In this case the adhesions will be :—

   (*a*) Fibrous, if only synovial granulation or cartilage destruction has been present, *i.e.*, the articulating bones are intact ; this usually occurs after trauma and tuberculosis, when *Fibrous True Ankylosis* results.

   (*b*) Bone may form between the granulating bone ends when the articular cartilage is partly or wholly destroyed, as in acute pyogenic arthritis, when *Bony True Ankylosis* occurs.

2. Around the joint (*False Ankylosis*), when either much blood clot after trauma, effusion after perisynovial infection, as in gonorrhœal fasciitis, or contracture in the scars of burns or lacerations, leads to fibrosis in the tissues around the joint ; this is thereby rendered incapable of movement, and is often fixed in a deformed position. Such false ankylosis is, of course, always fibrous, as no granulating bone surfaces are involved.

Clinically ankylosis is usually obvious, the joint being fixed and rigid, often in a flexed or semiflexed position from the muscle spasm in the pre-existent disease ; for which reason, as well as from disuse, atrophy and marked muscle wasting are present, but the muscles are not in spasm unless active joint disease is present at the time of examination. All attempts at active and passive movements are useless; they produce no pain in bony ankylosis, though this is nearly always elicited if the ankylosis be fibrous as some slight movement occurs between the joint surfaces on manipulation.

The joint is often apparently enlarged and the bone ends obvious, as the result of the muscle wasting and abnormal position, and in some cases where dislocation has occurred as the result of the previous disease, the end of one bone may be actually unduly prominent.

The *diagnosis* is usually easy, but it must be remembered that a generalised muscular spasm, generally without wasting, will produce joint fixation and absolute lack of movement on manipulation when the spasm usually becomes more marked; such a condition is met with in *hysteria*, and also in *malingering*, where the lack of wasting, general spasm, and often of complaint of pain, with a history of sudden or gradual onset after injury, usually will establish a diagnosis. Should any doubt exist, the patient can be placed under the influence of a general anæsthetic, when in hysterical or malingering cases the spasm of the muscles will relax and the joint move normally; X-ray films, of course, will eliminate bony ankylosis.

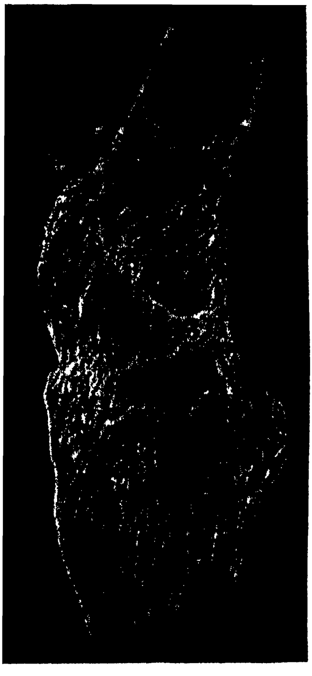


Fig. 309. Partial bony ankylosis of the knee joint.

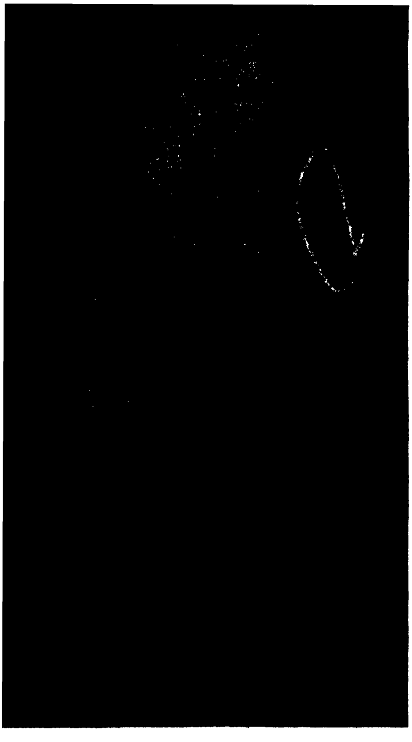


Fig. 310. Bony ankylosis after excision of the knee joint.

The *treatment* varies according as (1) true, (2) false ankylosis exists, but in either variety great care must be taken to ascertain that no active disease exists before any attempt is made to correct malposition in the joint, and it must be realised further that there is always considerable risk of lighting up the old infection when the fibrous or bony repair tissue is disrupted and encapsuled colonies or micro-organisms thus released. Treatment always aims at the correction of deformity, and, where possible, at the re-establishment of a movable joint.

1. *True Ankylosis.* In this condition, where the joint surfaces are destroyed and the bones united by either bony or fibrous tissue, the joint can be re-established only by division of this tissue, remodelling of the bone ends, and the insertion of some substance, usually fascial autografts, to prevent reunion; these arthroplasties are by no means easy of performance, are liable to produce recrudescence of disease, and often are not successful in their results. For these reasons many surgeons are content to leave the joint alone, and merely correct the deformity by means of an osteotomy through one or both of the adjacent bones (Chapter XXI., p. 715).

2. *False Ankylosis.* Here the fibrosis is in the muscles and fasciæ around the joint, which in itself is often normal; hence treatment aims at freeing the periarticular adhesions, either by forcible movement under anæsthesia or by tenotomies and fasciotomies, with subsequent movements of the joint to prevent adhesions reforming; but as both these manipulations are very liable to be followed by recrudescence of the primary disease, the best result to be hoped for is usually re-ankylosis in a corrected position.

INJURIES OF THE JOINTS

Any trauma in the nature of a strain is very liable to cause injury to the synovial membrane and ligaments and tendons incorporated in the capsule of a joint; moreover, such lesions may involve the bones entering into the formation of the articulation, in which case a "fracture-dislocation" will result (Chapter XV., p. 442). These conditions have been fully dealt with in Chapter XV., but it must be noted that following the hæmarthrus consequent on synovial damage the blood effusion in and around the ligamentous structures of the capsule organises, and consequent fibrosis, with true or false ankylosis, is bound to occur. This inflammatory reaction will lead, therefore, to a stiff and partly disabled joint, unless physiotherapeutic measures (massage, faradism and movements) are resorted to early so as to ensure rapid absorption of exudate and to secure freedom from adhesions between the joint surfaces and in the tendon sheaths. A tendency to persistent effusion in the joint cavity, due to organisation of clot or granulations on the synovial epithelium, must be combated on the same lines; this further applies to effusions which occur in joints on first rising after long disuse of the limb.

It cannot be urged too strongly that prolonged splinting in all such cases is to be avoided, and, indeed, it is best not to adopt any other treatment than a firm bandage, which should be removed daily for the practice of active movements and massage till the effusion has disappeared, usually in a week or ten days, when the support should be discarded and the patient encouraged to use the joint, which in the case of severe injury can be supported for a short period by the application of a varicosan bandage, Unna's dressing, or strapping.

Furthermore, in all cases of joint injury, *i.e.*, sprains, an X-ray photograph must be taken as a routine, as by this means alone in some cases fracture into the joint or displacement of bones due to rupture of intra-articular structures can be detected. Should such complications be present, then the treatment must consist of immobilisation in a suitable position—usually flexion—for a period of at least three weeks, in order to limit callus formation and prevent myositis ossificans traumatica, both of which conditions are increased by massage and movement, and will tend permanently to limit the range of movement of the joint (see Chapter XIV., p. 410). On removal of the splints gentle movements and massage must be resorted to till the joint is restored to normal, often a slow and tedious process, as fibrous (or even bony) ankylosis may have occurred, and in the former case may necessitate gentle and repeated movements under anæsthesia.

INFECTIONS OF JOINTS

Varieties of Arthritis. Inflammation of joints, as elsewhere, may be acute or chronic, and due to irritation from any of the following causes :—

1. *Trauma.*
2. *Bacteria.* (*a*) Pyogenic :
    - (i.) Purulent : Streptococcus and staphylococcus.
    - (ii.) Diplococcal : Gonococcus, pneumococcus.
    - (iii.) B. coli—typhosus group—including dysentery.

   (*b*) Specific Granulomata :
    - (i.) Tuberculosis.
    - (ii.) Syphilis.
3. *Toxic.* Rheumatism — Gout — Rheumatoid and osteo-arthritis — Arthritis in zymotic fevers—Serum arthritis.
4. *Neuropathic Lesions.* Charcot's joints.

Effusion also may occur in—

(*a*) Certain blood diseases (hæmarthrus).
  1. Congenital : Hæmophilia.
  2. Acquired : Scurvy,
     Severe anæmias,
     Hæmorrhagic fevers.

(*b*) Diseases of neighbouring structures.
  1. Bone :
     (*a*) Osteitis.
     (*b*) Malignant neoplasms.
  2. Muscles and Fasciæ :
     (*a*) Suppurative lesions.
     (*b*) Gonococcal fasciitis.

So long as the infection is limited to the synovial membrane the disease is spoken of as a *synovitis ;* but if the cartilage, bone, or capsule becomes involved the condition of *arthritis* results, which will be seen commonly in all cases of severe or long-standing joint inflammation.

PYOGENIC INFECTIONS OF JOINTS

Purulent synovitis seldom occurs without rapid involvement of all intra-articular structures by the infection ; purulent arthritis thus rapidly results, and is a most serious, crippling, and not infrequently fatal condition.

The infection is usually strepto- or staphylo-coccal in acute cases, but may be due to any pyogenic organism which may have reached the joint either (*a*) by direct infection, in penetrating or severe lacerated wounds which is uncommon, and by infection from a focus in the articular bones in 50 per cent. of cases (see Osteitis, Chapter XVIII., p. 529), or (*b*) by blood-stream infection from a septic focus elsewhere in the body, *i.e.*, pyæmia.

Penetrating Wounds of Joints frequently give rise to much anxiety lest infection should occur, and in some cases as to whether the wound actually has opened the synovial cavity, a question which usually can be answered by gently manipulating the area, when glairy or bloodstained synovial fluid can be expressed from the lips of the wound if the joint cavity has been entered.

Exploration of such wounds with a probe must be avoided, as the risk of carrying infection from the superficial to the deeper regions of the wound track is very considerable.

Treatment. (1) Should the wound have entered the joint it should be excised, if possible, the joint cavity be cleaned with saline, and the synovial membrane and capsule sutured, the wound track being drained for twenty-four hours and then sutured if clean. The joint, meanwhile, is fixed in a suitable position, with extension; massage and faradism may be employed, but movements must be avoided for at least ten days.

Should infection occur, the joint will be treated as indicated on p. 594.

(2) If the wound apparently has not penetrated, it may be excised and sutured and the joint rested in extension splints as above.

Purulent Synovitis and Arthritis, whether due to infection from a wound or to the bursting of a pre-existent abscess into the joint cavity, usually in suppurative osteitis, present the same signs, and are acute and serious conditions, calling for prompt surgical interference if the patient's limb, and even life, are to be conserved.

In this matter a word of warning is necessary in regard to cases of suppurative osteitis close by a joint, or those where there is a neighbouring independent periarticular suppuration, as in gonorrhœal infections; for the very presence of an inflammatory reaction around and outside the capsule of a joint often results in a sympathetic synovial effusion, and it is little short of a tragedy to open and infect such a joint. This is a problem which frequently confronts the surgeon, and can be settled only by a careful study of the physical signs in each case.

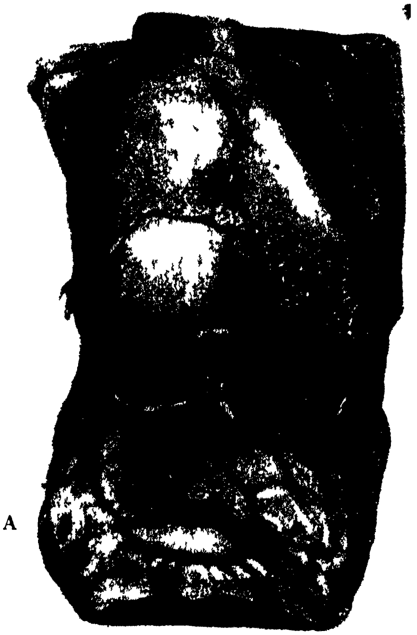


FIG. 311. Acute suppurative synovitis of the knee joint due to a penetrating wound (A).

Clinically the joint is distended with effusion, and all attempts at movement are extremely painful and resented, children screaming with fear on the approach of the surgeon lest attempts be made to move the limb. The muscles are rigid, and some œdema of the part may be present, the limb usually being in a position of semiflexion of the affected joint. In late cases, where the articular cartilage and capsule are destroyed, pus will be detected among the muscles, and if the joint is superficial the overlying skin is red, shiny and hot; pathological dislocation may be present, and is a common sequel in many cases. The patient is very ill, often being semicomatose or delirious, the temperature is raised, rigors are often present, the tongue dry and furred, urine scanty, and skin hot and dry; in fact, all the signs of an intense toxæmia are observed. Pyæmic abscesses often may present after each rigor, mostly in the lungs, where the signs of a purulent bronchopneumonia will be manifest.

Pathology. The synovial membrane is rapidly destroyed, and replaced by a layer of pus-exuding granulation tissue, which quickly overruns and destroys the articular cartilages from the edge inwards. The cartilage further becomes softened, eroded, and replaced by granulations at the pressure points, and may peel away in flakes around the edge of these ulcerating areas. Infection of the underlying bone is common, the surface lamellæ often necrosing and the Haversian canals filling with organisms and granulation tissue, the whole bone surface in the joint presenting a crumbling, ragged appearance from caries.

The joint cavity in the early stages is distended with a seropurulent opalescent exudate, which rapidly becomes frank pus. Later any intra-articular ligaments and the joint capsule become infected, granulate, and disintegrate, the pus then escaping among the fasciæ, tendons and muscles around the joint, which rapidly become infected, so that later pus may discharge by sinuses through the skin; disorganisation of the joint is now complete, and pathological dislocation occurs. Should resolution follow, ankylosis will result between the dislocated ends of the diseased bones, the limb being crippled, deformed and all too frequently useless.

Treatment. In the early stages this consists in aspirating the joint under aseptic precautions, a proceeding which may be repeated as often as necessary under local or general anæsthesia, as it is very painful. At the same time the joint must be fixed by means of an extension splint, usually Thomas's, or some modification. The pus removed should be cultured always, as vaccines or sera may be valuable in treatment, especially, as is often the case, if pyæmia subsequently develops.

Meanwhile both the local and general condition of the patient must be watched carefully, and should these be unsatisfactory the joint must be opened promptly at its most dependent part; on no account should the joint be washed out, but excessive pus may be removed by dry swabbing. The capsule should be left unstitched, and the wounds open, drainage tubes being passed down them to the joint capsule; one of these tubes should drain from the most dependent spot as the patient lies in bed, *i.e.*, behind the biceps in the knee joint, and from the posterior aspects of the hip, ankle and shoulder joints.

The limb must remain fixed on an extension splint, but inasmuch as ankylosis is almost certain to occur, the joint must be maintained in such a position that a functionally useful member will result should it remain fixed (see p. 588).

Should the patient's general or local condition so demand, no time must be lost in performing amputation, which often offers the only chance of saving his life, and means only the sacrifice of a limb which at best, and after long and painful treatment, will be stiff and often painful.

The *prognosis* of the condition is, of course, always grave, and especially so in those cases which are complicated by pyæmia.

Diagnosis. Should any doubt exist as to whether an effusion in a joint be purulent or not, no hesitation need be felt in aspirating, provided this can be carried out without risk of infection of the joint cavity.

Fluid withdrawn should be examined microscopically, as apparently clear synovia may teem with streptococci.

It may be quite impossible to determine if pus is in, or around, the knee joint, in which case incision must be made down to the joint capsule, when, if pus is encountered en route, drainage of this area should be carried out and the capsule left unopened ; should no pus be encountered, the joint must be explored. Usually, however, it is possible in these cases to determine whether the joint effusion is purulent by the general condition of the patient, though here suppurative osteitis presents great difficulty, and at times exploratory incision alone can clear up the point (Chapter XVIII., p. 537).

Chronic Suppurative Arthritis usually results from the rupture of a Brodie's abscess (Chapter XVIII., p. 542) or a tuberculous osteitis (Chapter XVIII., p. 547) into the joint cavity, when either a purulent or tuberculous synovitis (p. 598) will result. As the area is more or less acclimatised to the bacterial toxins, which are attenuated, this usually will be of a mild nature, although fibrous ankylosis often follows.

Treatment consists in fixation of the joint in a good position in plaster of Paris, with extension.

Secondary or Pyæmic Purulent Synovitis is usually a much milder disease, and often presents no signs beyond the rapid appearance of an effusion in a joint, often after a rigor.

The condition may occur in any septicæmia or pyæmia, but is very common after septic venous thrombosis and suppurative osteitis elsewhere in the body. Pain may be present, but is seldom severe, so that the local condition may escape notice until it has so far progressed that pathological dislocation occurs.

Treatment consists in aspiration, which seldom needs repeating, and fixation in a favourable position on an extension splint.

DIPLOCOCCAL INFECTIONS

Pneumococcal Arthritis is always purulent and usually met with in children during pneumonia, when other pyæmic manifestations, as peritonitis and meningitis, may be present ; rarely the joint infection may precede the pulmonary manifestation, in which case there is always severe toxæmia and the prognosis is very grave. In all other types the prognosis as regards the joint is fair, though ankylosis usually results. The condition is rare in adults, but not uncommon in children, both after pneumonia and pneumococcal otitis media.

Clinically the condition resembles any pyæmic joint in that there is a sudden, nearly painless effusion into the joint, which is distended and held in the position of greatest capacity. The large joints are usually affected and the condition is nearly always monarticular, but frequently progresses to disorganisation and pathological dislocation. The effusion is frequently large, and on aspiration the pus is thin and creamy, often of a greenish tinge, and contains numerous pneumococci.

Treatment consists, locally, in aspiration and fixation of the joint in a useful position on an extension splint ; this usually suffices to quiet the condition, but should it increase the joint must be opened, the synovial cavity closed, and drainage arranged down to it as for a pyarthrosis (p. 587).

The general condition and primary pneumococcal focus need attention ; vaccines and sera appear to be of use in combating toxæmia and M. & B. 693 must be given.

Where a pathological dislocation is discovered at the end of the illness it should be treated by extension of the limb, and when reduction has been effected thus, by fixation in a good position in a plaster of Paris splint for six weeks. Ankylosis nearly always results. In neglected cases excision of the joint usually offers the best solution.

Diagnosis. (*a*) From pyæmic arthritis due to other causes; this can be settled only by the finding of pneumococci in the pus and the presence of other foci in the body.

(*b*) The toxic form is very liable to be mistaken for the similar type of suppurative osteitis (Chapter XVIII., p. 537), and only the detection of pneumococci locally or elsewhere in the body, often in the post-mortem room, will establish the diagnosis definitely.

(*c*) Lastly, the condition may be mistaken for acute rheumatism; but its limitation to one joint and its painless appearance during pneumonia usually will establish a diagnosis.

Gonorrhœal Arthritis (Chapter VI., p. 85) always occurs secondarily to some primary focus elsewhere in the body, usually in the genito-urinary tract; this source of infection, however, may be so mild or so chronic as to have escaped the notice of the patient, and even of the practitioner, unless it is diligently sought for. As a rule the joint troubles manifest themselves about the third week after infection, just as the local discharge is clearing up. Usually the gonococcus can be recovered from the joint effusion, though in the early stages it may be very difficult to obtain, as it is present in very small numbers in the serous effusion.

Pathologically the synovial membrane is spongy, red and granulating, and in the later stages secretes pus, and extends over the articular cartilages as a veil-like, ulcerating pannus. The effusion, serous in the early stages, may become purulent. Articular cartilage is liable to be eroded and destroyed, with considerable fibrous true ankylosis; total disorganisation of the joint is rare.

In the vast majority of cases the infection commences as a periarticular fasciofibrositis, and there is always extensive inflammation, with serous or purulent exudate, from which many gonococci can be recovered, in the tissues around the joint capsule before the synovial membrane is actually involved. This leads to extreme periarticular fibrosis and false ankylosis, which renders the chance of obtaining a movable joint a very small one.

In a few cases, where gonococcal septicæmia is present, direct synovial infection may occur *via* the circulus vasculosus; in such cases the prognosis is far graver both as regards the joint, where suppuration is sure to occur, and as regards life, as malignant endocarditis and other complications are likely to result from the septicæmia (Chapter VI., p. 85).

Clinically two varieties of the disease are commonly met with :—

1. *Monarticular*, usually affecting a large joint, and often suppurating; the infection is usually primarily periarticular, but may be directly synovial. This type of arthritis is usually met with only in acute gonorrhœa.

2. *Polyarticular*, usually affecting small joints, particularly the sterno-clavicular, temporomandibular, vertebral, and tarsal, but also met with in large joints, frequently after trauma; most commonly only one of these large joints is affected, in conjunction with several smaller articulations. This type always occurs secondary to periarticular fibrofasciitis, the results of which may be so severe and crippling as to mask the joint condition, *i.e.*, gonorrhœal pes planus. Suppuration seldom occurs in this type, and should it take place is frequently periarticular; the arthritis is common in chronic gonorrhœa of a mild type which is often of itself giving rise to no symptoms.

In both types the patients are usually young adults in whom a history of recent gonorrhœa can be obtained and gonococci seen in films taken from the urogenital canal; but it must not be forgotten that the joint disease may be met with in adults and elderly people long after active gonorrhœa has ceased, and in young children and babies following accidental vulvovaginitis or infections resultant from birth or sexual outrages.

In both cases the history is so typical as to be almost pathognomonic of this type of joint infection, and also of the fibrofasciitis (Chapter XIII., p. 394). The onset is absolutely sudden, perhaps following some extra use or trauma, and often the patient will first notice intense pain when rising from rest or moving in bed; in many cases the exact time of onset will be volunteered. The pain is agonising, and the patient crippled with the tender, swollen and immobile part. The tenderness can be noted to extend in the tissues some way beyond the joint capsule, and to be present both on active and passive movements and on pressure. The region is hot and the skin often red and shiny. It must be remembered, as in all gonorrhœal complications (Chapter VI., p. 84), that the genital discharge often ceases or greatly diminishes with their onset. The further history is also characteristic, for if left alone, or treated by rest or liniment by the patient, the condition improves steadily up to a point, and then remains stationary. with considerable disability, effusion and crippling. Considerable joint effusion and very marked periarticular thickening are usually present, and in some cases, especially where one large joint is affected, suppuration is liable to occur in and around the joint, as is shown by increase of pain and local redness and heat. Where weight has to be borne by inflamed fasciæ and tendons, these often stretch, and deformities result, as in the foot, where pes planus commonly occurs (Chapter XXI., p. 704).

Treatment, apart from that of the primary infection (Chapter VI., p. 83), consists in absolute rest of the inflamed area, which should be immobilised in a useful position in plaster of Paris or an extension splint for at least six weeks after all pain has ceased. Ankylosis is the usual result, periarticular adhesions accounting for most of the disability; all attempts at wrenching are usually followed by recrudescence of the disease, due to release of encapsulated colonies of gonococci, and are not, therefore, to be encouraged. Should suppuration occur aspiration may be tried, but usually the joint needs opening and swabbing out, after which it rapidly settles. Vaccines are often very valuable in these arthritic cases (Chapter VI., p. 83).

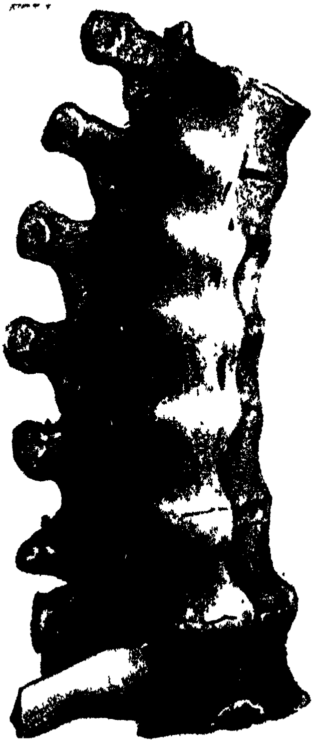


FIG. 312. False ankylosis (bony) of the vertebral column secondary to gonorrhœal fasciitis. "Poker back."

One of the most crippling afflictions of young adults is the "poker back," which follows infection in and around the intervertebral joints, the whole spine being stiff and held very erect and rigid. Flat foot is another serious and intractable result, and needs prompt handling by wrenching and fixation in plaster of Paris in an inverted and corrected position for three months (Chapter XXI., p. 597).

Diagnosis may present some difficulties, both from acute rheumatism, especially in children, and rheumatoid arthritis in young women; but in both these conditions the flitting of the trouble from one large joint to another and gradual increase in severity usually establish the diagnosis, which can be confirmed by negative swabs from all possible sources of primary infection.

The polyarticular variety in the small joints is liable to be confused with that met with in zymotic fevers and serum joints, while dysenteric arthritis has also been confused; but the history, increasing severity of local symptoms subsequent to the onset of infection and absence of a primary gonococcal lesion will establish the diagnosis. The same points serve to distinguish ordinary adolescent flat foot from the gonorrhœal variety.

Typhoid Arthritis occurs not infrequently during enteric fever, usually toward the end of the disease. One or more points may be affected, and suppuration not uncommonly supervenes, the pus containing numerous typhoid bacilli.

Clinically the onset is usually insidious and in a large joint, where the first sign of the trouble noted is not infrequently a pathological dislocation seen on the patient rising from bed. Occasionally pain may be noticed.

Treatment consists in aspiration if pus is suspected, and fixation of the joint in a useful position in an adequate splint; should dislocation have occurred, extension must be employed and the joint be reduced before fixation is carried out.

Occasionally purulent infection of joints with B. coli occurs in a septicæmia, or complicates a B. coli pyelitis or urethritis, but this is of rare occurrence. Treatment is as for typhoid arthritis.

Dysenteric Arthritis occurs as a late complication of bacillary dysentery, especially the B. shiga type, and usually affects many large joints, which become distended and acutely painful, the patient being quite unable to move. Suppuration is rare in these cases. Erythematous or urticarial rashes may occur.

The condition resembles gonococcal rheumatism, though here the small joints are more infected; rheumatic fever, where there is no intestinal disturbance and cardiac changes are often met with; and serum arthritis, which may occur where serum has been given in these cases. A similar condition is met with in the East following bites from rats and other rodents, and is known as *Japanese rat-bite fever*.

Treatment consists in rest, administration of aspirin and arsenic, and treatment of the intestinal infection. The administration of antidysenteric serum in these cases is followed by rapid improvement in the joint condition, but painful serum arthritis in the small joints often occurs in about ten days, and if not expected gives rise to suspicion of a relapse.

TUBERCULOSIS OF JOINTS

Tuberculous infection of joints is of a chronic nature, and by far the commonest infection met with, so that in some countries its crippling effects are little short of a scourge. In England and most civilised countries, however, efficient hygiene and early recognition and treatment of the condition have rendered this form of the disease less common and far less crippling.

The disease is commonest in childhood and early adolescence, but may occur at any age, and is so commonly met with in old persons that the special term " senile tuberculosis " is given to this variety.

Two varieties of infection are met with: (1) That in which the synovial cavity is infected secondarily to the bursting into the joint of a pre-existing focus of tubercle in the adjacent bone metaphysis (Tuberculous Osteitis, Chapter XVIII., p. 547). This form is by far the commoner, particularly in the hip, and is met with especially in children and adolescents, where the unossified epiphyseal cartilage forms a line of small resistance along which infection from the bone shaft spreads into the synovial membrane lining the joint cavity. Occasionally the sudden eruption of a mass of tuberculous material from a bone abscess through the articular cartilage into a joint is accompanied by fever and a brisk local reaction, with pain and sudden effusion, giving rise to the so-called "acute tuberculous joint."

(2) The type in which synovial infection occurs directly through the blood stream *via* the circulus vasculosus, a variety more commonly met with in adults, and seen most commonly in the knee joint. The infection in this type is always milder, and the prognosis better, both as regards the function of the joint and duration of the disease; as might be expected, there is early and great effusion from the synovial inflammation, and inasmuch as this may be patchy in distribution and intensity of reaction, scattered areas of fibrosis and caseation will occur, giving rise to an irregular synovial thickening in some instances, which has earned for this variety of the disease the appellation of " König's Nodular Synovial Tuberculosis."

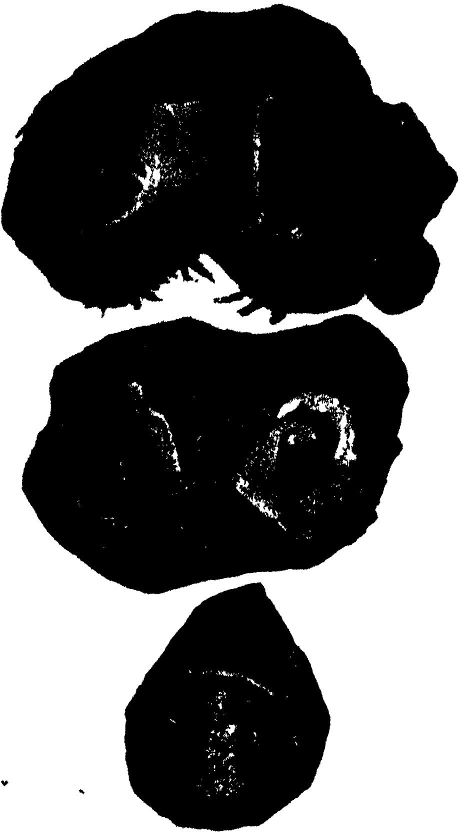


FIG. 313. Tuberculosis of the knee joint, showing caries of bone and flaking of cartilage.

Clinically, whichever type may be present, the onset is usually insidious, being more gradual in those cases where pre-existing bone disease causes pain, muscle wasting, and slight synovial thickening with a small effusion (Chapter XVIII.) before the joint is actually invaded.

When infection occurs, effusion, which is usually serous but may contain tuberculous caseous debris (tuberculous pus), manifests itself, and may cause some pain if excessive, but this is not marked so long as the infection remains localised to the synovial membrane, which at this stage can be felt thickened and pulpy. This is due to the presence in the synovial membrane of masses of tuberculous granulation tissue and giant-celled systems, the whole presenting a gelatinous œdematous appearance, the surface endothelium being replaced by rough, pale granulations, among which caseous foci appear; these break down and burst into the joint cavity, liberating tuberculous pus therein. In the primary synovial type caseation rarely occurs, and the disease remains localised to the membrane for some long time, so that in these cases the stage of effusion with thickened synovial membrane and little pain may persist for some months, making no apparent progress.

In the primary osseous type, however, caseous foci form and burst, conveying the infection about the joint, and the diseased subsynovial bone causes more intense inflammation in that membrane, granulating masses of which invade the edges of the articular cartilage, intra-articular ligaments, tendons and the joint capsule, all of which are eroded and destroyed. The articular cartilage being avascular, and therefore offering little resistance, is most rapidly and extensively destroyed, both by the synovial granulations at its edges and by deposits of tubercle on its surface; flaking of the cartilage is, however, rare in tuberculous arthritis.

So soon as the articular cartilage is attacked, the clinical picture alters considerably; pain becomes marked, especially on movement, so the joint is held immobile, for which reason generalised muscle spasm becomes marked, and should this relax, as in early sleep, the movements of the diseased cartilaginous surfaces on each other result in "starting pains." The spasm of the muscles tends to mask the flabbiness and loss of tone in these structures, which is so marked a feature of the earlier stages of the disease, but the disuse serves to increase and emphasise the muscle wasting.

Movements, which in the earlier stage were only limited and probably could be forced to the full without pain, become almost or quite absent in the affected joint, and any attempt to force them is not only resented strongly, but very painful. The joint cavity is lost, the space around the bones being filled with tuberculous granulations, among which lie pockets of caseous material, which may liquefy and form tuberculous pus.

The limb is often drawn into a deformed position by the pull of the strongest groups of spastic muscles around the joint, but no actual shortening can be detected until, owing to the progress of the disease, the destruction of capsule, intra-articular tendons and ligaments allows the spastic muscles to disarticulate the diseased bone ends.

Pathological dislocation, with actual shortening of the limb, and considerable deformity result, the bone ends being displaced in the direction of the pull of the strongest groups of muscles acting on them.

Throughout the disease the temperature of the skin around the infected area is raised, but no redness is seen, unless pus forms under the surface, a phenomenon which gained for the condition of tuberculous arthritis the name of "white swelling." This swelling of the part is, however, usually more apparent than real, being mainly due to the undue prominence of the diseased, thickened, and sometimes displaced bone ends among the wasted muscles of the region.

The general signs of tuberculosis will be present, a hectic daily temperature, with a maximum nocturnal rise about 6 p.m., night sweats, wasting, and the persistent " spes phthisica," while other tuberculous foci may be detected in the body, especially in the lymph nodes, lungs, peritoneum, or genito urinary tract. It must be emphasised that the coexistence of bone or joint tuberculosis with lesions of a similar nature in other viscera is of very grave prognostic significance.

To epitomise briefly, it will be seen that the disease falls clinically and pathologically into three stages :—

1. *The stage of effusion,* where the infection is limited to the synovial membrane, which is pulpy and granulating. Pain and muscle spasm are slight, but there is marked loss of tone, flabbiness and wasting of the muscles around the joint, the movements of which, though painless, are limited in extent in all directions.

This stage is longest in duration in the primarily synovial type of tuberculosis, met with most commonly in adults, and should the disease be arrested in this stage a useful and movable joint is to be expected. In those cases where a pre-existing osseous focus exists, this stage lasts as long as the focus is confined to the bone, or the subsynovial tissue around the joint cavity.

2. *The stage of invasion of cartilage and joint cavity* following eruption of tuberculous material into the joint through the synovial membrane or articular cartilage, or invasion of the cartilage at its periphery by granulating synovial membrane. There is a sharp change of signs, pain becomes marked due to movement of the diseased surfaces, which are consequently held immobile by generalised spasm of the muscles around the joint. Should these relax and allow movement, " starting pains " result. Wasting becomes more marked, and the joint assumes a deformed position, due to the pull of the strongest groups of muscles around it, but no actual shortening of the limb occurs. The joint is occupied by granulations or caseating tuberculous pus.

3. *The stage of destruction of the ligaments and capsule, with disorganisation of the joint.* Pathological dislocation leads to shortening and deformity, the bone ends being displaced in the direction of the pull of the strongest muscle groups attached to them. The joint cavity is obliterated and filled with masses of tuberculous granulation and caseous tissue.

During any of these stages, and under suitable treatment, repair may take place, usually with adhesions between granulating bony and synovial surfaces and the formation of dense fibrous tissue, among which colonies of tubercle bacilli are often encapsuled. Thus repair in tuberculous arthritis leads to fibrous true ankylosis. In other cases, however, the infection spreads through the capsule into and among surrounding muscles, tendons and tendon sheaths, and extensive infiltration of the tissues, with subsequent formation of tuberculous abscesses, results. These ultimately point through the skin, or in the case of the spine and hip into the bowel or kidney, and many sinuses result, which present the typical pale, exuberant tuberculous granulations.

These sinuses usually become secondarily infected with pyogenic cocci, and the infection spreads to the joint and diseased bone, where it often masks the original tuberculous infection ; so that in many old museum specimens, where sinuses and secondary infection have been present, the tuberculous lesion is no longer obvious, but the typical abundant coral-like osteoperiostitis and bony ankylosis seen in pyogenic osteitis are obviously present.

It cannot be impressed too strongly on the student that tuberculous arthritis is repaired by fibrous ankylosis ; bony ankylosis is present only in those cases where sepsis has been superimposed on the original infection.

Treatment consists essentially in fixation of the joint in a useful position under extension, best by means of a well-made and carefully moulded plaster of Paris splint, applied under anæsthesia if any trouble is experienced in dealing with the muscle spasm causing the deformity. This is known as the "conservative method" of treatment, and is usually successful if properly and thoroughly carried out. The joint must be kept absolutely immobile for a period of at least six months after the cessation of all active disease, best manifested by disappearance of pain, and usefully checked by noting the appearance of the bones in X-ray films.

Should pain persist after the application of a plaster splint, then the first cause to think of is that immobilisation is imperfect: this may occur from cracks or flaws in the plaster, usually due to muscle spasm, or from the fact that the splint does not control the muscles adequately, *i.e.*, fix not only the diseased joint, but also those above and below, in which case a new plaster should be applied, preferably under anæsthesia on an extension table (Chapter XIV., p. 417).

It is also important to realise that further muscle wasting, consequent on disuse, will occur under the plaster, thus enabling movements to occur, and as this will have reached its maximum in a month to six weeks, the plaster of Paris splint will need renewal at the end of that period in all cases, a change often further necessitated by absorption of joint effusion and consequent lessening in girth of the limb.

As a general rule, plaster will be needed for from six to nine months, when it may be removed and replaced by a light extension splint for a like period. Faradism and light massage may be permitted after fifteen to eighteen months, but on no account must movements be attempted, as thereby fibrous adhesions are broken down and the condition lit up again.

In the meantime the patient must be kept in the open air and sunlight, failing which ultra-violet rays are of value if applied to the bare skin, and nourishment, general health and hygiene are carefully attended to. Excellent results are to be seen from the sunlight treatment practised at such institutions as those at Alton and Leysin.

Should sinuses exist around the joint in late cases, skeleton splints or plaster of Paris with windows must be used to secure immobilisation, when these will heal usually within three months, whereafter the treatment proceeds as above. Failure to heal under perfect immobilisation indicates the presence of sequestra or very extensive bone disease due to secondary infection and calls for operative interference.

By these conservative measures almost any tuberculous joint can be cured in from two to three years, fibrous ankylosis in a good position usually resulting, the time varying with the extent of the infection and the stage of the disease at which treatment is commenced. Thus pure synovial tuberculosis is cured in many cases in eighteen months, and a movable joint may be expected, whereas once cartilage or bone is involved, fibrous ankylosis is the best result to be expected, and that not under two years.

It thus follows that it is essential that tuberculosis of bones and joints should be diagnosed as early as possible and promptly and efficiently treated on these conservative lines.

Operative treatment consists in arthrectomy, which is only justifiable in those cases where (1) sinuses persist or X-ray films show sequestra; (2) other considerations, such as the occupation or circumstances of the patient, make it impossible for him to give up the prescribed time or be sufficiently under supervision, *i.e.*, peasants attending from long distances away and agricultural labourers in whom a stable bony ankylosis is essential. In such cases the joint should be laid open (Chapter XXII., p. 728), the diseased bone and synovial membrane carefully removed, and the healthy bone ends apposed and fixed in plaster, bony ankylosis being aimed at, but by no means always resulting.

Amputation may have to be resorted to if other serious foci of tuberculosis exist elsewhere and the joint is badly disorganised or secondarily infected; in such cases it should not be delayed, as the improvement in general health and in the other foci following ablation is usually both rapid and marked.

It is more commonly necessary in old persons, *i.e.*, senile tuberculosis.

Diagnosis. As already pointed out, a diagnosis is essential in the early stages of tuberculous disease if a useful joint is to result, and this may be by no means easy, for at this stage many other conditions may give rise to signs simulating synovial infection. Such are tuberculous or other chronic osteitis (syphilitic or septic), with or without Brodie's abscess, and early sarcoma of the bone, in both of which conditions there is slight muscle wasting and loss of tone, some thickening and synovial effusion, and slight pain; but joint movements are not limited and X-ray films will establish the diagnosis, when the conditions need prompt treatment.

Again, gonorrhœa and rheumatism may give rise to trouble where an acute effusion follows the bursting of an abscess into the joint cavity, but the severity of the pain in these diseases and the signs elsewhere, together with the X-ray appearances visible in tuberculosis, will establish a diagnosis.

In the later stages, when the joint is swollen and muscle spasm, wasting and deformity are marked, diagnosis is usually easy and obvious, but here again Clutton's joints (p. 605) and rarely chronic pyæmic or typhoid arthritis may simulate the condition; in these cases X-ray films may show very similar appearances, and reliance must rest on the history and presence of other lesions, though muscle spasm and wasting are generally much more marked in tuberculous arthritis.

Hæmophilic joints may give rise to difficulty, though here the history and absence of X-ray changes will make the condition evident. Rarely effusion produced by flipping with a wet towel in cases of malingering may give rise to a suspicion of synovial tubercle, but usually signs of trauma can be detected and the effusion varies according as to whether the patient has a chance of inflicting further injury; similarly hysterical joints may cause doubt.

In cases where many sinuses and secondary infection exist, with a disorganised joint, it may be difficult to determine if a primary tuberculosis ever was present.

X-rays in Diagnosis. X-ray examination should be a routine in all cases, and though it will show no abnormal appearances in a joint with primary synovial infection, yet in all other cases abnormal bone conditions can be demonstrated. Thus in those cases where a synovitis exists secondarily to a bone lesion, the bone can be seen to be rarefied and present the clear area of an abscess (Chapter XVIII., p. 549), while slight feathery new bone (osteoperiostitis) can be detected at the periphery.

In later cases, where the cartilages are destroyed, the carious and feathery bone ends can be seen abnormally approximated, and still later displaced on each other.

Occasionally in elderly persons, especially in the shoulder, much difficulty may be experienced in diagnosing synovitis secondary to caries sicca from rheumatoid arthritis, but apart from X-ray examination, the type of pain will determine the condition at once. Pain is present in both conditions, but whereas it gets steadily worse in tuberculosis with use of the joint, in rheumatoid arthritis it is very bad on commencing movements, but improves or disappears with continued use of the joint.

For Caries Sicca, see also pp. 532, 660.

SYPHILIS OF JOINTS

(A) In *acquired syphilis* towards the end of the *second stage* joint pains, often accompanied by transient effusions, may occur for a few days, and tend to relapse, forming one form of " recurrent hydrops " ; such joints tend to be symmetrical, *i.e.*, corresponding joints are affected on both sides of the body, as is the tendency in all syphilitic lesions of bilateral organs. Pathologically the condition is due to a spirochætal infection, and the synovial membrane can be seen to be much congested and spirochætes recovered from it; the effusion is serous and sterile in most cases.

In the tertiary stage (1) **a true gummatous synovitis** is by no means uncommon, being seen most often in the knee. The synovial membrane is irregularly invaded, thickened and definitely nodular to the feel. There is considerable effusion, the onset being insidious, the pain absent or slight. Usually the condition is symmetrical, one joint being affected two or three weeks before the corresponding joint on the other side of the body becomes involved ; several joints may be implicated and the condition is very chronic. The patient usually walks about, but in time muscle wasting and loss of tone, and general laxity of the ligaments, with abnormal mobility, manifest themselves ; bursæ in the neighbourhood may be involved, or gummata appear in the superficial tissues.

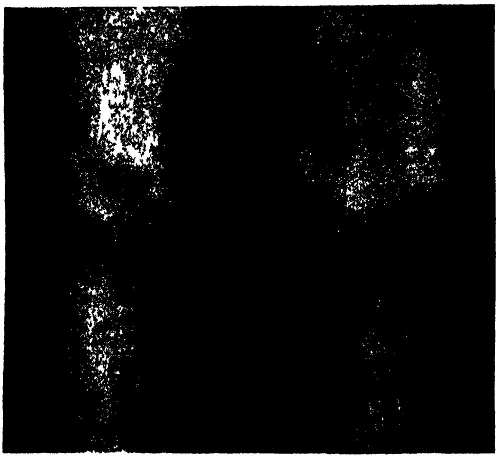


FIG. 314. Bilateral effusion into the knee joints.
(" Clutton's Joints.")

(2) Synovial effusion may occur secondarily to gummatous infection of the bone (Chapter XVIII., p. 556), usually carious in type, or of surrounding muscles and tendons. In this case the thickening is mainly perisynovial, and the condition is apt to be mistaken for tuberculosis, a diagnosis further complicated in cases of gummatous osteitis by the rarefaction shown on an X-ray film (Chapter XVIII., p. 558).

(3) Rarely **gummatous osteochondritis** occurs, with softening and fibrillation of the articular cartilage, which proliferates at the edges, giving rise to lipping. An effusion is present which varies in amount, but pain is not marked, which serves to distinguish the condition from tuberculosis or rheumatoid arthritis (Virchow).

(B) In *congenital syphilis*. Osteochondritis in infants with separation of the epiphysis due to replacement of the epiphyseal line by avascular caseous debris, leads to joint effusion and disability and has been discussed already on p. 559.

Clutton's Joints (symmetrical gummatous synovitis) occur in children at or before the age of puberty, and consist in a diffuse gummatous infiltration of the synovial membrane, usually of the knees, which are both affected, but one more so than the other. Clinically the synovial membrane may be slightly thickened and considerable effusion is present, pain is markedly absent, and fair use of the joint exists, though it is often weak and unstable. Other stigmata of the congenital type are usually present (Chapter VI., p. 127), especially sabre tibiæ and bowed thickened femora due to osteitis. In many cases the synovial thickening is not appreciated clinically, and the condition merely appears as a hydrops.

In all cases the Wassermann reaction is positive and treatment consists in rest locally, with massage to promote absorption of the effusion and a full course of antisyphilitic remedies (Chapter VI., p. 121).

TOXIC JOINT DISEASES

Under this heading are included, as in the case of specific infections (Chapter VI.), a number of infections the ætiology of which is obscure, and the main stress of which in many cases falls on the synovial membranes or perisynovial tissues of the joints.

Acute Rheumatism, as already discussed (Chapter VI., p. 136), is an acute affection most often met with in children or young adults, and liable to relapses. The chief stress falls on the heart, especially the endocardium of the valves, and joints, and the constitutional signs have been discussed briefly (p. 136).

The arthritic infection is usually sudden in onset, frequently in a red-haired and freckled child, and generally affects large joints, the inflammatory reaction being first manifest in one joint, and rapidly passing to others in no set sequence. The inflammation in one joint tends to settle as another gets infected. Family history is often marked.

Clinically there is intense pain, with effusion into the joint, the skin over which is red and swollen, and may show erythematous or even purpuric rashes (Schönlein's purpura rheumatica). Movements are very restricted, but usually no marked muscle changes can be detected. Other joints become affected rapidly. There is a white blanket-like or a brown furred tongue, acrid sweat, raised temperature and weak, rapid pulse; cardiac irregularities and murmurs may be present, rheumatic nodules (p. 234) may be detected in the subcutaneous tissues and are of grave prognostic significance.

Treatment consists in absolute rest for a long period, weeks or months, on account of the cardiac condition, combined with administration of aspirin grs. v–x, t.d.s., or sodium salicylate in similar doses. Massage is to be avoided.

Subacute Rheumatism is met with in children, often subsequent to an acute attack, but sometimes as a primary manifestation of the disease;

the onset is insidious and the child anæmic and off colour, complaining of abdominal pain and occipital headaches, and vague transient pain around the bone ends and joints, which are all too prone to be dismissed as "growing pains." Cardiac lesions are common in these cases, as also *pes planus* (Chapter XXI., p. 698), which is of interest to the surgeon, as it is frequently the condition for which the child is brought to hospital.

It cannot be impressed too strongly on the student and practitioner that a painful flat foot occurring in a child under twelve years of age is always a rheumatic manifestation, and must be treated as such by rest and salicylates. Massage and exercises must be strenuously avoided, as they not only aggravate the local condition, but invariably bring on cardiac valvular lesions.

The *diagnosis* rests between *gonorrhœal* and *pneumococcal* arthritis; in the former the child's age and the presence of cardiac lesions will be strongly in favour of rheumatism, though careful examination must be made to see that no gonorrhœal focus, such as vulvovaginitis, is present; in the latter, pulmonary or peritoneal lesions can be detected. *Rheumatoid arthritis* (Still's disease) may give rise to difficulty in diagnosis, but here slight splenomegaly is present and the small joints tend to be more affected. Occasionally a *pyæmic or tuberculous arthritis* with a sudden effusion may cause trouble in diagnosis, especially in a deeply placed joint like the hip.

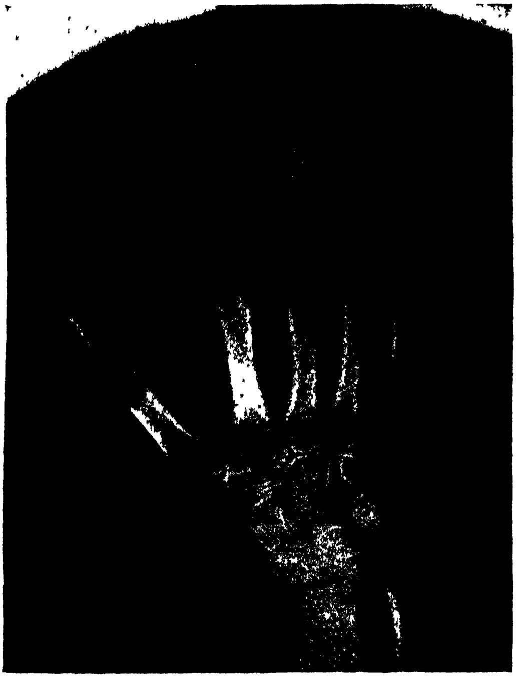


FIG. 315. Rheumatoid arthritis of the hand. Note the approximation of the joint surfaces due to absorption of cartilage.

Gout has been discussed already on p. 135 and is usually met with in elderly persons, the great toe joint being very prone to infection. Other joints, the knee, wrist, etc., may suffer a deposit of sodium biurate in their cartilage, and neighbouring bursæ may be affected. Recurrences are common and often follow dietetic indiscretions.

Clinically the onset is sudden, usually about 2 a.m., with acute and agonising pain in the affected joint, so that the patient is irritable and dreads any attempt at movement or jarring of the affected limb. The tissues around the inflamed joint are purplish, swollen and œdematous, so that the condition may be mistaken for one of cellulitis unless care is exercised in examination and eliciting the history.

The *treatment* consists in giving Vin. colchici ♏ xv, t.d.s., till pain ceases, and in avoiding dietetic excesses. The inflamed area needs rest, support and protection.

The *diagnosis* is usually easy, but occasionally an *acute arthritis* or infection of a *Charcot's joint* may give rise to difficulty; as already pointed out, the condition is liable to be mistaken for a periarticular cellulitis, or more rarely an acute osteitis may be mistaken for a gout, though here the patient's general signs are far more severe, due to the toxæmia.

Rheumatoid Arthritis, Osteoarthritis, Arthritis deformans, are a series of names given to various joint diseases of a toxic or degenerative character, the ætiology of which is unknown; they are closely connected with the absorption of toxins and micro-organisms from septic foci in the body, such as diseased tonsils, pyorrhœa alveolaris, sepsis deep round the fangs of the teeth, chronic sinus suppuration, and intestinal stasis. Moreover, there can be no doubt that trauma and strenuous occupations play a great part in determining the joints which will be affected.

Whenever such foci are found they should be removed, but it must be realised that damage done to joints is a *fait accompli*, and that return to normal conditions cannot be expected, though prevention of further damage may be hoped for.

Both clinically and pathologically two types of the disease are met with, and are by some authors regarded as separate entities, while by others they are thought to be different stages of the same disease.

1. *The polyarticular type*, in which the lesions are mainly perisynovial, the onset acute and children or young adults affected. The name Rheumatoid Arthritis is especially applied to this form.
2. *The monarticular type*, where the main stress of the infection falls on the articular cartilage, bone and synovial membrane being secondarily affected, and where lipping, etc., leads to palpable deformity. Such cases occur usually in elderly patients of the working classes, and are often named osteoarthritis, or, should much bony proliferation and deformity exist, arthritis deformans.

(1) **Polyarticular Toxic Arthritis** occurs usually, as already pointed out, in young adults or children, more often females, in whom frequently no definite primary septic focus can be discovered, though the patients often may be constipated or have leucorrhœa.

Pathologically the main stress of the disease can be shown to fall on the perisynovial structures, which are thickened and infiltrated, presenting all the signs of inflammatory reaction to a low grade of infection.

Thus the fasciæ and tendon sheaths are invaded by lymphocytes and plasma cells, and show marked œdema and ultimately fibrosis, with consequent false ankylosis or limitation of movement by a fusiform thickening around the joint. No organisms can be found, but some authors claim to find a marked acidosis in the affected tissues.

The bones, deep to the synovial reflection, become carious and rarefied, and ultimately the overlying articular cartilage, owing to malnutrition, becomes absorbed and replaced by fibrous tissue, so that on X-ray examination the bone ends are seen much rarefied, and closer together than normal owing to loss of the articular cartilage; the ends are, however, clearly defined, and no new bone formation is present. Usually the small joints are more and earlier affected, and it is characteristic that bone absorption is irregular, so that deformities occur, ulnar deviation being characteristically seen in the hands.

Clinically the onset is usually fairly acute after a period of gradually declining health, associated with anæmia and a peculiar earthy discoloration of the skin; occasionally the onset is so sudden and painful as to suggest a gonorrhœal infection. There is increasing pain and stiffness in the affected joints, usually those of the hands and feet, though large joints may be and usually ultimately are affected. The gradual onset of periarticular thickening often gives rise to a typically spindle-shaped appearance at the joint; this is accentuated by the marked wasting of the muscles around. Movements are very limited, and deformities and contractures, usually flexion, occur early and tend to increase, leading in many cases to absolute crippling of the unfortunate patient. There is little or no effusion into the joint cavity generally.

Constitutional signs suggestive of a mild toxæmia are usually present, with often a palpable spleen, which in children may be a marked characteristic, as described in *Still's disease*, where also bronchitis may be present.

Treatment is usually of little avail, and consists in rest in bed with local splinting to prevent deformity and the application of mild counter-irritant and sedative applications, of which Ung. Gaultherii or Scott's dressing are best. Hot air or brine baths may be of benefit when the acute stages are past, as also spa treatment at Bath, Harrogate, Droitwich or Matlock, in this country, or one of the numerous Continental spas.

Local septic foci should be removed if present, and cultures taken for vaccines which may be of benefit, but the wholesale removal of sound teeth, healthy tonsils, etc., cannot be condemned too strongly. In cases of leucorrhœa, iron and arsenic tonics and the use of astringent douches may be useful; cultures should be taken with a view to eliminating gonorrhœa, and the preparation of vaccines which may be very beneficial. Constipation should be treated by regular attention to the bowels, and administration of thymol grs. ii, b.d. in cachets, while if it is obstinate benefit may result from the use of extensive lavage on the Plombières system. Some authorities believe in the administration of alkalies to counteract local acidosis and give sodium bicarbonate in large doses

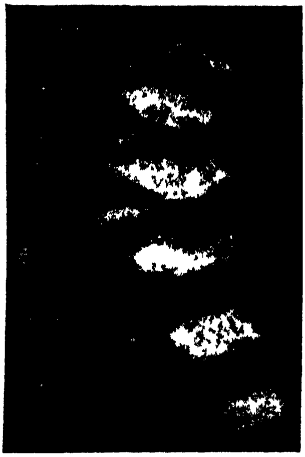


FIG. 316. Osteoarthritis of the spine.

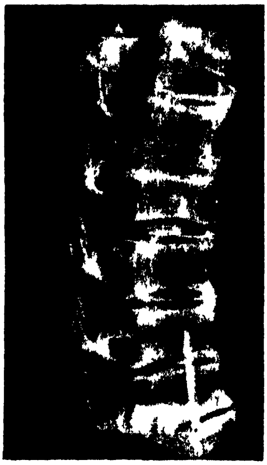


FIG. 317. X-ray film of the spine, showing absorption of the intervertebral discs.

Diagnosis, as already pointed out, is mainly from gonorrhœal fascio-arthritis, from which the disease often can be diagnosed only by careful cultures from all possible sources of primary gonorrhœal infection proving negative, though the gradual onset and steady increase in symptoms in most cases of rheumatoid arthritis are in marked contrast to what is characteristically seen in gonococcal infections (see pp. 85, 596). Acute rheumatism may give rise to doubt in the diagnosis, but the cardiac signs, and characteristic acrid sweat, with the predilection for large joints, are characteristic. Dysenteric, febrile and serum arthritis may be sources of error, but their onset in the course of some disease should prevent any mistake arising.

(2) **Monarticular Toxic Arthritis** usually first affects one of the large joints, but subsequently involves other joints, both large and small. The disease usually occurs in elderly people, with bad teeth, and its first seat of infection is often determined by some local trauma, so earning it the appellation "traumatic osteoarthritis." The disease may remain localised to the one joint for a considerable time, but other joints subsequently show arthritic changes, or, on the other hand, several other joints may be involved in rapid succession following the appearance of the disease in the original joint.

Pathologically no organisms are found in or around the joint, but the first manifestations of toxæmia are noticed either in (1) the synovial membrane, or (2) the articular cartilage, and frequently in both these structures contemporaneously. Thus, clinically, two distinct types of the disease, the synovial (villous) and cartilaginous (osteoarthritic), are met with, and in addition in many cases a mixture of these exist in the same joint.

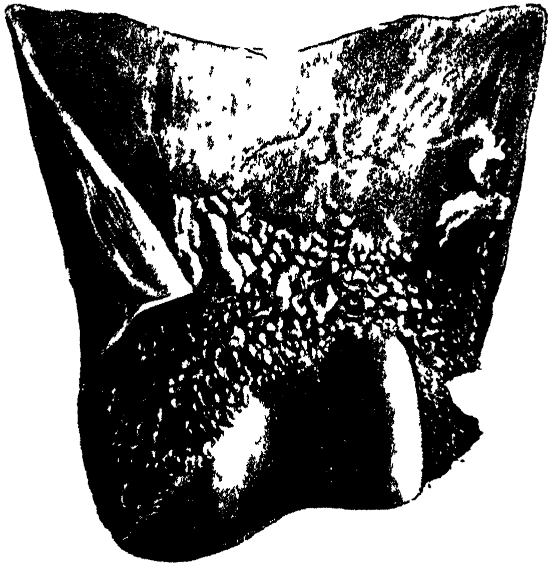


FIG. 318. The subcrureal pouch opened to show "synovial tags" due to hypertrophy of villi in chronic toxic synovitis.

(*a*) *The synovial membrane* becomes thickened and its papillæ much hypertrophied, so that its free surface resembles a pile carpet in the early stages and considerable serous effusion occurs into the joint cavity and communicating bursæ. Later degenerative changes take place, with deposit of fat in the synovial fringes and tags, leading to the condition known as "lipoma arborescens," where these hypertrophied tags form a series of pedunculated fatty masses hanging into the joint cavity; here they may get nipped and aggravate the effusion, or be torn off, and so constitute fibrous "loose bodies" (Chapter XVII., p. 513). Degenerative changes occur in the fat, and lead to calcification and chondrification of the hypertrophied synovial villi, which give rise to a creaking sensation on movement, and are very liable to break off and form "loose bodies" (Chapter XIX., p. 611) in the joint cavity, thus leading to exacerbation of the effusion and disability in the joint. Moreover, the thickened and hypertrophied synovial membrane tends to grow over the articular cartilage, which becomes vascularised and replaced by scar tissue, or, rarely, exfoliated.

(*b*) *The articular cartilage* shows degenerative changes both in the matrix and cells. The matrix becomes softened and later fibrillates and splits away, being replaced by scar tissue, in consequence of which the articular cartilage disappears, a condition more rapidly brought about at the pressure points where the friction of movements causes the softened cartilage to be worn away. The cells proliferate rapidly and in an irregular manner, tending to invade the synovial membrane, and to burst through and erupt into the joint, where they give rise to yet a third variety of loose body (Chapter XIX., p. 611). Further, at the edges of the cartilage the proliferating cells will grow out irregularly into the tissues, giving rise to the formation of cartilaginous outgrowths (*Ecchondroses*, Chapter VIII., p. 203), which can be palpated through the skin if the joint be superficial, and give rise to the "lipping" so characteristic of this type of the disease; these ecchondroses later calcify or ossify as the result of degeneration consequent on malnutrition.

The underlying bone undergoes invasion by granulation tissue from the synovial membrane and becomes the seat of caries, being unduly porous, with large Haversian canals, full of granulations, the openings of which can be seen as pits on the articular surface, where it is denuded of cartilage. Consequent on this porosity the bone softens, eburnates and becomes shiny as a result of the friction of movements; at the same time it wears away in grooves in a hinge joint such as the knee, and shows gradual flattening and expansion in an enarthrosis such as the shoulder and hip. Tendons and ligaments in the synovial cavity become thinned, frayed and frequently atrophy and disappear, the muscle acquiring a new extracapsular attachment to the bone. Bursæ around the joint become distended with fluid, their synovial membrane being affected as is that in the joint; their

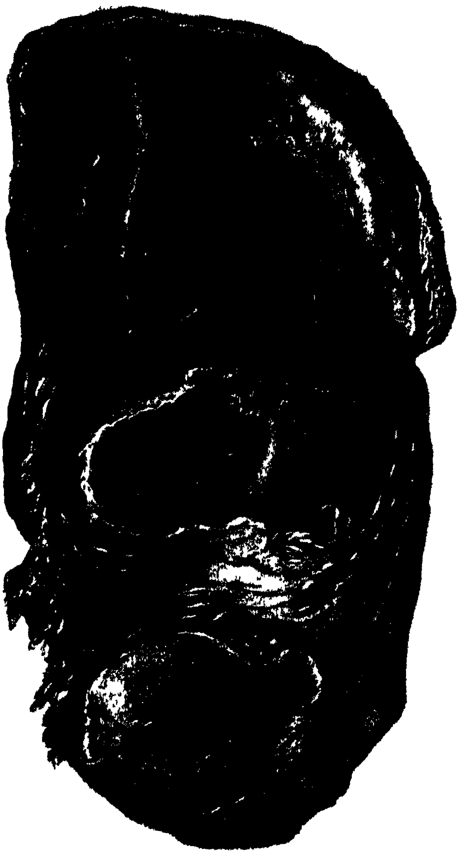


FIG. 319. Osteoarthritis of the knee joint, showing lipping, cartilage erosion, and grooving of bone.

communication with the joint cavity frequently becomes nipped off where they protrude through the capsule, and thus one form of " Morant Baker's cyst " is formed. It should be remembered that osteoarthritis never causes true ankylosis of a joint except in the spine.

Before leaving the pathology of this condition attention must be drawn to the great frequency with which "**Loose Bodies**" occur in joints affected with osteoarthritis; these are usually cartilaginous, but may be fibrinous and are frequently multiple, being derived from :—

1. Hypertrophied fatty synovial tags in lipoma arborescens—fibrous.
2. Calcified synovial tags—cartilaginous.
3. Growth of erupted cartilage cells—cartilaginous.
4. Breaking off of ecchondroses—cartilaginous or bony.

Clinically the condition usually manifests itself somewhat suddenly, attention being drawn to the joint by some local trauma, or it may come on gradually in a previously damaged or much used joint, as after sprains in elderly people, or in the knee joints of charwomen. The joint first affected is usually a large one, the knee, hip, shoulder or elbow, but sometimes the ankle, tarsus, or carpus first cause trouble; in all cases other joints ultimately will show changes, if, indeed, examination does not show them to be already present, often apparently in a more marked degree than in the joint actually complained of. The condition is particularly common in the knees of fat women.

The patient complains of pain and stiffness, with sometimes creaking of the joint, which are worse after resting and improve with use; thus the symptoms are most noticed in the morning on rising from bed.

On examination the affected joint is found to be swollen, and may be slightly warmer than the corresponding joint on the other side; the synovial membrane is thickened and effusion is present, with the characteristic creaking and grating which can be felt and may be heard on movement, and which varies from a fine crepitus to a sensation of scrunching gravel. In superficial joints " lipping " can be detected at the articular margins ; this may be slight in amount or form huge irregular masses (arthritis deformans) in the cartilaginous type ; it is usually absent in the synovial variety.

Muscle wasting and spasm are present, with limitation of movement, attempts to elicit which are painful. Frequently bursæ around the joint are distended, and may form tense cystic tumours, moving freely in the tissues around the joints and under the skin (Morant Baker's cysts). Rarely the bony masses around the joint may be so large as to limit movement, or they may break off and lie loose in the tissues. There is usually some anæmia and the teeth are at times foul with pyorrhœa; or other septic foci, such as constipation, otorrhœa or sinus disease, may be present.

The joint condition is always aggravated by damp and cold, whether climatic or incidental on occupation; thus sufferers come in great numbers in the autumn and after working in the wet, *i.e.*, charwomen at "spring cleaning," and much improvement occurs in dry summers or after travel in warm, dry climates. Exacerbations of the disease, with increased pain and effusion, are frequent, and usually follow trauma or exposure to damp and cold.

The *X-ray appearances* are characteristic in osteoarthritis, the joint showing distortion and flattening of the bone ends, which are rarefied and unduly close together owing to loss of articular cartilage. At the same time there is usually more or less new bone formation around the edges of the articulation, due to lipping, though it must be remembered that no shadow will be present unless the ecchondroses are calcified or ossified, although clinically well-marked lipping may be detected.

In villous arthritis no bone lipping can be detected, but owing to the replacement of the cartilage by fibrous tissue the bone ends are unduly close together, an appearance which in the early stage may be limited to one side of a joint only, if the changes have only occurred in that situation. There is usually some rarefaction of the bone just below the cartilage, which leads to a characteristic "light line" just behind the articular surface, which will serve to distinguish this condition from the more diffuse and homogeneous rarefaction of either rheumatoid arthritis or tuberculous caries, in which latter case also some feathery new bone will be present at the bone edges.

Treatment is not satisfactory, but aims primarily at removing septic foci in the hope of arresting the disease, and locally in devising some means to ameliorate the joint condition and symptoms arising therefrom.

Thus septic teeth should be removed, sinus disease treated and pus cultured, with a view to the preparation of a vaccine, although vaccine therapy is disappointing in these cases. Intestinal antiseptics, such as thymol, or salicin, may be given, or drugs such as potassium iodide or guaiacum resin.

The joint condition may be treated by various means, but usually little relief results, though symptoms may be ameliorated temporarily. Perhaps the most comfort arises from keeping the joint at an even temperature by covering the region in a knitted woollen "cap," or in thermogene wool, while in some cases the same result may be obtained by treatment with Scott's dressing applied on strips of lint under strapping, which is especially valuable in those cases where much effusion is present.

Hot air baths, diathermy, and ionisation all may give relief in certain cases, or on certain occasions, but prolonged rest or massage usually aggravates the local condition. In certain cases, however, where much disability, pain and lipping exist, it may be justifiable to aim at ankylosis of the joint, which can be obtained by fixing the limb in a useful position in plaster of Paris for some months. Most relief is afforded by sending the patients abroad to warm, dry climates, such as Egypt or South Europe, where the symptoms disappear; failing this, treatment at an English spa, in these cases preferably Bath, or at Aix, is often beneficial.

Operation may be undertaken in monarticular cases, either with the object (*a*) of getting a movable joint, as recommended by Robert Jones and Albee, by chipping away osteophytes, remodelling the bone ends, and inserting a fascial graft between them (arthroplasty); or (*b*) of fixing the joint by some form of arthrodesis as advocated by Max Page, a proceeding which, on the whole, gives a better result, and is certain to relieve pain. This is always advisable in the pure villous synovial type, where the hypertrophied synovial membrane must be removed entirely, together with all the fibrosed and apparently healthy articular cartilage.

Diagnosis is usually easy if osteophytes are present, but *Charcot's joints* may give rise to trouble on a superficial examination, though in these the cheerful way in which the patient uses a disorganised joint, together with signs of nervous disease, should remove all doubt as investigation of the case proceeds.

The synovial variety may be mistaken for an atrophic Charcot, chronic gonococcal, or tuberculous lesion of the joint, and care and X-ray examination are necessary before diagnosing this somewhat rare condition.

Static Osteoarthritis occurs in joints distal to malunited fractures, or in cases where deformities higher up the limb lead to an abnormal line of stress and pressure-bearing in the joints below. The condition is also met with in "fracture-dislocations," especially if the cartilaginous surfaces are not accurately apposed, and the joint line re-established, and in these cases bone cells from exposed bone actually may escape into and grow in the joint.

The former condition is typically seen in the flat foot and arthritis resulting from uncorrected deformity in Pott's fracture, or the arthritis of knee and ankle following untreated deformities at the hip joint, while the latter type is all too frequently seen in fractures of the carpus, Colles's fracture, and Pott's fracture when the ankle joint is involved.

The arthritis follows undue strain on ligaments and abnormal pressure on cartilaginous surfaces, with degeneration, chronic inflammation, and the formation of masses of cartilage and bone in and around the structures entering into the joint. The condition, therefore, resembles most closely the osteoarthritic form of toxic and monarticular arthritis, with which it is easily confused, and indeed is sometimes alluded to as traumatic osteoarthritis. There is marked pain and crippling deformity.

Clinically the patient gradually notices increased pain and stiffness in the joint, and ultimately may be unable to use it from these causes. Examination reveals lipping, effusion and creaking, with limitation of movement; of active movement only in the early stages, but of both active and passive later when ligaments and muscles are contracted and fibrosed on one aspect of the joint to hold it in its abnormal position. The causative deformity must be sought for and treated.

Treatment consists in prophylaxis by accurate anatomical reposition of fragments in fractures, and especial care in restoring the joint line in fracture-dislocations, and in prevention of deformities by suitable care and appliances. Should these have occurred and the joint condition be early, osteotomies may be used to correct them, but in late cases excision and arthrodesis of the affected joint will alone cure the pain and disability. This should be combined with correction of the deformity in cases where this is gross. The subject is dealt with in Chapters XIV. and XXI., where it is more fully discussed.

Heberden's Nodes are a series of rounded osteophytic outgrowths from the ends of the phalanges, which occur in connection with arthritic changes in the interphalangeal and carpometacarpal joints in agricultural and other manual workers. These changes are somewhat akin to both the poly- and monarticular forms of arthritis, in that many small joints of the hand are affected, with perisynovial infiltration and with destruction of cartilage; this leads to well-marked ulnar deviation of the fingers, and at the same time bone rarefaction, with marked osteoperiostitis causing thickening of a fusiform nature around the joints.

Clinically the hands and sometimes the feet are involved in elderly agricultural or other manual labourers, women also being affected. The hands are typically gnarled and deformed, there being marked wasting of all muscles, which makes the knuckles unduly prominent; a condition rendered more obvious by the thickening of the perisynovial tissues and lipping of the bones, often of a nodular type (Heberden's nodes), which give rise to a spindle-shaped thickening around the joints.

There is marked ulnar deviation of the digits. Pain is marked and joint movements restricted and accompanied by crepitus, the condition being worse in cold, damp weather, and the joints very often being painful for a day or so before a change in the weather occurs.

An X-ray film shows marked lessening of the articular gap due to cartilage absorption, with rarefaction of bone ends, and the presence of rounded osteophytes (Heberden's nodes). Well-marked ulnar deviation is present in old-standing cases, often with definite loss of bone substance, and marked atrophic changes in all the bones of the hand.

Serum Synovitis, and **Synovitis in the course of Zymotic Fevers and Influenza**, usually affect only the small joints of the feet and hands, but occasionally in severe cases may cause painful effusions in larger joints.

The trouble usually manifests itself about ten days after serum injection, and the same time after the onset of scarlet fever, or, more rarely, influenza or other zymotic fevers, there being a painful effusion into all the affected joints, which are held motionless and flexed; there is a waxy, puffy condition of the soft parts in the neighbourhood, and urticarial or erythematous rashes may be present. The sternoclavicular and temporomandibular joints are seldom, if ever, involved, this serving to diagnose the condition from gonorrhœal arthritis, should any doubt exist.

Treatment consists of rest and the administration of aspirin, when the condition clears up in a few days.

NEUROPATHIC ARTHRITIS

Neuropathic arthritis, presumably of a degenerative nature, is met with in nervous lesions, most commonly in tabes dorsalis (locomotor ataxia), a parasyphilitic lesion due to fibrosis, following gummatous changes in the postero-lateral columns of the spinal cord, which appear shrunken and wasted; hence the name Tabes. Such joints, however, rarely may occur in other lesions of the central and peripheral nervous system, namely:—

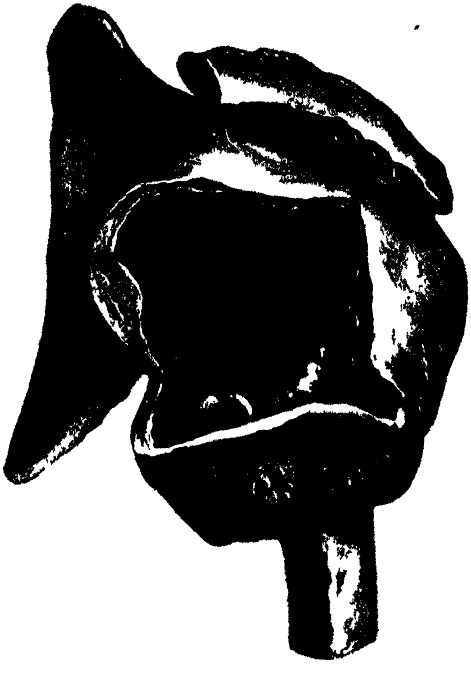


FIG. 320. Atrophic Charcot's disease of the shoulder joint.

1. Upper motor neurone lesions, *i.e.*, between the brain and anterior horn cells of the cord.
   (i.) Cerebral diplegia, general paralysis.
   (ii.) Cord lesions, postero-lateral sclerosis, disseminated sclerosis.
2. Lower motor neurone lesions, *i.e.*, in the anterior horn cells or below.
   (i.) Anterior poliomyelitis, spina bifida manifest and occult.
   (ii.) Injuries and diseases of peripheral nerves.
   (iii.) Myelitis.
3. Mixed lesions, syringomyelia, tumours of the cord and meninges.

The lesions are, next to tabes, most commonly seen in syringomyelia, when they are generally met with in the upper extremity and are of the atrophic type. Inasmuch as this type of arthritis was noted and described by Charcot, of Paris, in connection with tabes dorsalis, such joints are often known as **Charcot's Joints.**

Two varieties of neuropathic joints are met with clinically:—

1. The *hypertrophic*, where an extensive disorganisation and rarefaction of the joint and the articular ends of the bones are accompanied by excessive osteophytic outgrowths.

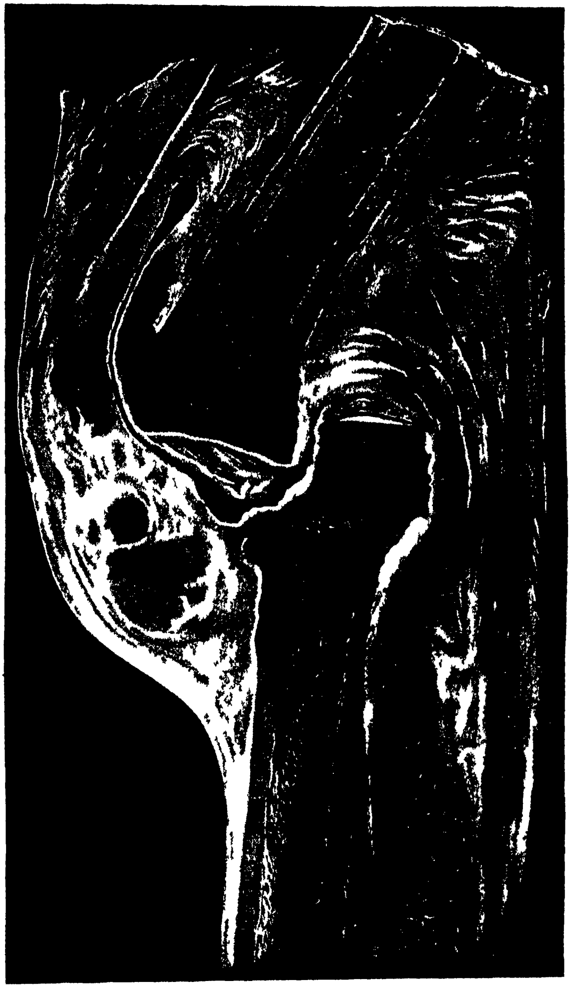


FIG. 321. Charcot's knee (hypertrophic). Note the posterior dislocation of the tibia and wearing away of bone, showing the dislocated joint has been walked on.

2. The *atrophic*, where rapid rarefaction and absorption of the bone occurs, with marked synovial infiltration and effusion.

But little is known of the pathology of this condition save that there is rarefaction of bone, presumably due to decalcification and destruction of cartilage, with marked infiltration by granulation tissue of the synovial membrane, capsule of the joint, and other intra- and extra-articular structures, so that these become destroyed and the joint entirely disorganised, pathological dislocation occurring.

Nothing is known as to what factors determine whether new bone formation occurs or not, but certainly this is commoner in tabes and in the lower extremity, while the atrophic variety is more often met with in syringomyelia and in the upper limb. It would appear that the changes in the hypertrophic form are comparable to those met with in the osteoarthritic variety of monarticular toxic arthritis, while those in the atrophic resemble the changes seen in the synovial or villous type of the same disease; but in both cases a difference exists, as the neuropathic condition is painless. Owing to the nervous lesion the patient cannot appreciate pain and will walk about cheerfully on the disorganised joint so long as it is sufficiently stable to allow him to do so; hence the rarefied bone gets worn away in a marked degree by joint movements, and the manner and position of the bone-grooving show that these have taken place regularly in the dislocated and disorganised joint.

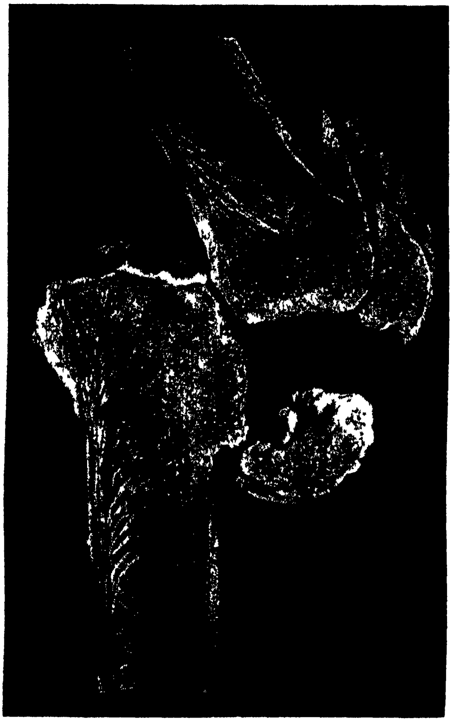


Fig. 322. The bones in a hypertrophic Charcot's knee. The same specimen as *Fig.* 318.

Clinically there are many points in common to both varieties of Charcot's joint; thus the patient usually attends because the joint is unstable, or because of rheumatism in the limb, which inquiry will show at once consists really of the neuropathic stabbing pains (lightning pains) which occur so characteristically in tabes, and are in no way connected with the joint condition. Similarly, an inquiry as to whether the joint is painful may be answered in the affirmative, but further questioning will elicit that the pain is of a sharp stabbing character and comes and goes in the limb "like a knife." Such pains are always worse in wet weather.

Usually the patient will stump in quite cheerfully on the joint, which can be seen to be unstable, or else use the limb freely if the upper extremity be affected, which is not so frequent. The gait is often of the typical reeling and stamping variety seen in tabes, the forehead is wrinkled (to correct the ptosis of the upper lid), but the lower face smooth and unfurrowed, and on examination the knee-jerks are absent and Argyll Robertson pupils can be demonstrated, *i.e.*, the pupils react to accommodation, but not to light. Marked loss of sensation generally can be detected on pinprick. There is usually marked thickening of the tissues around the affected joint, which does not pit on pressure, and this swelling may extend for some distance up and down the limb, and is very characteristic. Movement is usually possible in any direction in a manner impossible in a normal joint, and is, of course, quite painless.

The *hypertrophic form* is the more common, its onset is usually gradual, the limb becoming more unstable as the disorganisation of the joint occurs. On palpation huge osteophytic masses can be felt around the distorted joint margins; these may break loose and be mobile on the bone, or may interlock and prevent or limit movement.

The *atrophic form* usually is seen in the upper extremity, and often occurs quite suddenly, there being sudden and severe pain in the affected area, as occurs in any " tabetic crisis," the limb being swollen and useless and great effusion appearing in the joint. The condition clears up in a few days, when the limb is seen to be flail and the joint distended and disorganised.

X-ray films show marked rarefaction and destruction of the bone ends, which are frequently displaced from their normal relationship to one another. In the atrophic form nothing else is seen, but in the hypertrophic variety masses of new bone are visible around the bone ends, to which they may or may not be attached.

Treatment is of little avail and consists in the use of some light splint to support the limb when the joint is unstable; it cannot be emphasised too strongly that the fitting of heavy and complicated apparatus is useless, as the nervous condition and ataxia render the patient unable to support it. The nervous condition should be treated, if tabes is present, on the lines indicated in Chapter VI., p. 121, when some amelioration of the general symptoms may be expected.

An operation to produce arthrodesis is occasionally worth considering, but its results are very uncertain.

Diagnosis usually presents no difficulties if the nerve lesion is recognised, but should this be overlooked, osteoarthritis, rheumatoid arthritis, or even gout may be diagnosed.

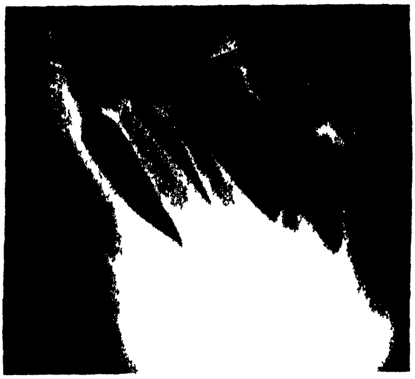


FIG. 323. X-ray film showing absorption of the bones of the metatarsus in Charcot's disease.

Complications. Charcot's joints are very liable to and little resistant to infection, so that *suppuration* is a frequent and serious complication; it may arise either from a blood-stream invasion or by direct contiguity, usually from an adjacent perforating or gummatous ulcer, especially in the knee and tarsal joints.

Clinically the condition is quite painless, but the part is hot and red, and fluctuation may be detected. The temperature will be raised and the general signs of infection present.

Treatment consists in amputation of the infected limb above the diseased joint, local interference being very unsatisfactory both as regards cure of the local infection and because of the liability to cause septicæmia.

Hæmarthrus, as already indicated on p. 587, may arise from a variety of causes, the most common of which is trauma; it is seen also in certain diseases, most commonly in hæmophilia and scurvy, and as a result of the invasion of a joint cavity by a bone sarcoma (Chapter XVIII.).

Traumatic hæmarthrus results from contusions, sprains and fracture-dislocations, and is dealt with in Chapter XV.

Hæmophiliac Joints occur in males, usually as the result of some negligible trauma, the knee joint being most commonly affected. The hæmorrhage occurs in the synovial membrane, and thence into the joint cavity, which becomes distended with fluid blood ; the condition is liable to relapses, and in old-standing cases the thickened synovial membrane and capsule assume an orange colour from deposits of hæmatoidin, due to altered blood pigment, an appearance characteristic of the condition.

Clinically there is a history of sudden and often apparently causeless effusion into a boy's joint, which is seen to be tensely distended under a normal-looking but slightly warm skin. The synovial membrane may be thickened, as also the perisynovial tissues. Pain is often severe and the limb held flexed and motionless. Inquiry at once will elicit that the patient is a " bleeder."

Treatment consists in rest and the application of a pressure bandage, with gentle massage and passive movements in about ten days to promote absorption of the effused blood and prevent adhesions in and around the joint. Needless to say, no attempt must be made to aspirate the joint.

Horse serum may be given or calcium chloride administered by the mouth. In old-standing cases the joints may be so damaged that supporting splints are necessary. Vitamine K may be of help.

Diagnosis is easy once the hæmophiliac history is obtained, but in its absence traumatic synovitis or tuberculosis of the joint probably will be diagnosed, and disaster will follow inevitably should the surgeon perform aspiration under the former assumption, as the patient may bleed to death.

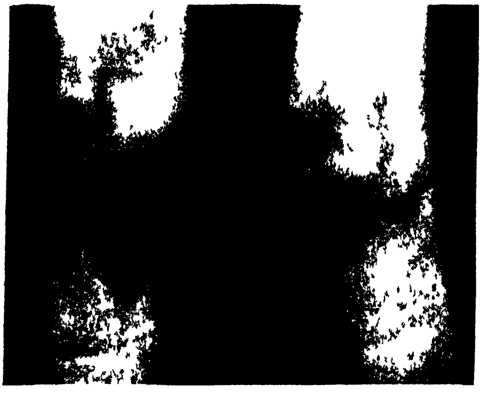


FIG. 324. Bilateral effusion in the knee joints of a hæmophiliac.

Prognosis should be guarded, as relapses are likely, and restricted movement of the joint often results.

Scorbutic Hæmarthrus is similar in all respects and needs treatment on the same lines. It is common in cases of scurvy and can be diagnosed easily in the presence of other signs of the disease, especially the spongy, bleeding gums.

Sympathetic serous effusions, which may later become infected and so give rise to pyarthrus, with all the signs of suppurative arthritis, may occur in connection with infection of bones and soft tissues in the region of the joint, and have been dealt with in Chapters V., XIII. and XVIII.

Similar effusions may occur secondarily to sarcoma or myeloma in the bone, and are discussed in Chapter VIII., but it may be well again to draw attention to the fact that such are frequently diagnosed as tuberculosis of the joint, unless careful examination is made and an X-ray photograph taken.

HYSTERICAL JOINTS

This group covers a large number of cases in which no actual organic lesion can be demonstrated by clinical or X-ray examination; such cases usually occur in neurotic women, but are seen in men and even in young children; any joint may be affected, but rarely more than one, the knee, elbow or hip being most frequently the seat of trouble.

Clinically the outstanding feature of such cases is the extreme pain and hyperæsthesia, which is out of all proportion to the physical signs. The affected joint is held in any position by a generalised muscle spasm, usually in full flexion or extension, very little muscle wasting is present, and tone is normal. Effusion in the joint is in the vast majority of cases conspicuous by its absence; in cases with a malingering element, external application of an irritant, especially at the knee, may lead to slight effusion, but then considerable œdema in localised areas around the joint or bruising of the skin will be present. Attempts at movement are strongly resisted in all directions, and any request to move the joint in a given direction is at once productive of a "negative" spasm of the opposing muscles. Under deep anæsthesia all spasm disappears, but it often returns with consciousness.

X-ray examination is, of course, negative.

Treatment is often very difficult and unsatisfactory. Elimination of sources of mental worry, the encouragement of mental occupation of a healthy nature, the removal from sympathetic friends and, if necessary, institutional treatment may be advisable. Confidence in the doctor is essential, and in some cases the services of a reputable psycho-analyst are invaluable.

Strong emotion is productive of "miraculous cures," this being the type of case so much benefited by religious revivals, Christian Science, or the psychic effect produced by religion and the sight of "cures" at Lourdes and other well-known places of like reputation. It is in this type of case that the quack or "bonesetter" obtains his greatest successes.

Occasionally dramatic cures can be obtained by movements under anæsthesia, the limb being held in a different position to that previously occupied and moved before the eyes of the patient as consciousness is recovered.

CHAPTER XX

CLINICAL MANIFESTATIONS OF DISEASES IN INDIVIDUAL JOINTS

In this chapter will be found an account of the commoner infective processes met with in the various joints of the body considered individually; only the clinical aspects of the various conditions are here dealt with, the pathology and general signs of the various inflammatory processes having been discussed in detail in the previous chapter.

THE SACROILIAC JOINT

This auricular-shaped articulation exists between the lateral aspect of the upper two segments of the sacrum and the ilium, and is situated on either side of the midline, below and beneath the dimple which always marks the position of the posterior superior iliac spine. The joint, which is a diarthrosis permitting of gliding movement mainly in the anteroposterior direction, often consists of an imperfect cavitation in the fibrocartilage, but has a definite synovial membrane, the whole being surrounded by dense ligaments, which normally preclude anything more than the slightest movements.

Under certain conditions, as in pregnancy in the female, and in all cases where compensatory movements are necessary in ankylosis of the hip joint, the sacroiliac ligaments soften and stretch, permitting, as can easily be demonstrated, considerable gliding and rotatory movements of the pelvic girdle on the sacrum. From the imperfect nature of the joint cavity and the close proximity of the bones, it follows that infections are nearly always osseous in origin, and that should effusion occur, the dense nature of the surrounding ligaments will lead to considerable tension and pain, a condition further aggravated by the presence of the lumbosacral cord (fourth and fifth lumbar nerves) which is passing down immediately anterior to the joint to enter into the sacral plexus in the pelvic hollow; two other nerves, the first and second sacral, are in close proximity to the joint, so that pain will be referred down the course of the sciatic nerve.

Further, the psoas lies in front of the joint and slightly to the outer side, while the rectum lies to the inner side, other relations being the iliac vessels and ureter, which cross in front of the joint.

Thus it will be seen that when the joint contents burst through the ligaments, the abscess may track in various directions, which are enumerated in order of frequency:—

(*a*) Through the great sacrosciatic notch into the buttock, pointing above and behind the trochanter and deep to the glutei.

(*b*) Down the side of the rectum to the ischiorectal fossa where the abscess points.

(*c*) Into the rectum.

(*d*) Into the psoas sheath and thence along the pelvic brim to Poupart's ligament, forming a psoas abscess.

(*e*) Backwards deep to the erector spinæ.

It should be remembered that sacroiliac disease is uncommon.

(1) **Injuries.** **Sacroiliac strain** (see Chapter XVII., p. 488).

(2) **Acute Infections** are usually synovial and may occur in rheumatism, gonorrhœal infection, or rheumatoid arthritis; acute septic osteitis of the neighbouring bones rarely may involve the joint.

Clinically there is pain in the lower lumbar region and some tenderness on pressure over the region of the posterior iliac spines, in which region slight fulness and œdema may sometimes be detected; referred sciatic pain in the hip and knee is commonly present.

(3) **Chronic Infection** is nearly always tuberculous, but osteoarthritis and, rarely, Charcot's disease may be met with in this joint.

Tuberculous Sacroiliac Disease is commonly met with in adults, children very seldom being affected; the disease always starts in the neighbouring cancellous bone, usually the ilium, where an X-ray film may demonstrate a carious focus, abscess formation being, therefore, relatively common; the abscess points in one or more of the directions indicated above.

Clinically the onset is gradual, with pain referred down the sciatic nerve and worse on exertion, while a limp gradually develops, the patient putting all the weight of the body on the sound side, and therefore dipping towards the affected side, as in congenital displacement of the hip (Chapter XXI., p. 675), and no other disease.

On examination some fulness may be detected behind the joint, and in children by rectal examination; in adults pelvic examination may reveal fulness if an abscess is present. The pelvis is tilted down and forward on the affected side, and the lower limb held rigid, flexed and everted (as in the early stages of hip disease, p. 624), but examination shows that all passive movements of the hip are full and painless if the pelvis is fixed. Wasting may be marked in the muscles supplied by the sciatic nerve (hamstrings and glutei), but not in the adductors and quadriceps, which are supplied from the lumbar plexus.

Compensatory lordosis to correct flexion, and scoliosis, with its convexity to the affected side to correct a lateral dip, are met with in old-standing cases, where also an abscess or sinus may occur; should an abscess burst and a sinus persist into the rectum amyloid disease usually supervenes relatively early, and the prognosis is correspondingly grave. In old-standing cases, with much bone disease, pressure on the iliac crests or forcible attempts at separation of the anterior iliac spines will cause pain in the sacroiliac region, but this sign is absent in early cases.

X-ray films should always be taken, and will show caries and slight fluffy osteoperiostitis in tuberculous cases, lipping in osteoarthritis, and disorganisation in Charcot's disease, where also signs of tabes dorsalis will be present.

Diagnosis is easy if a careful examination is made, but there can be no doubt that many cases of sacroiliac disease of all sorts get passed as *sciatica* from lack of local examination.

Hip joint disease is another fruitful source of error, especially in tuberculous cases, but the limp towards the affected side is pathognomonic of sacroiliac disease, if present, and careful physical examination as indicated above will show that the hip joint movements are full and painless and the wasting confined to the muscles behind the joint. An X-ray film, of course, will clinch the diagnosis if bone disease be present.

Treatment. This consists in complete rest, which can be efficiently obtained only by a plaster of Paris spica fixing the pelvis and both hips, which should be widely abducted. In less severe, *i.e.*, non-tuberculous, cases, sufficient rest can be obtained by a tight pelvic band, combined with rest in bed; but tuberculous cases need fixation in plaster for nine months after all pain has ceased. Should abscesses be present, either in septic or tuberculous osteitis, the joint should be approached from behind by a horseshoe incision with removal of part of the ilium, and all disease be curetted away, after which fixation should be employed as above, a window being left in the casing so that dressings can be applied to the wound. The prognosis is not good.

THE PUBIC SYMPHYSIS

This is normally a synchondrosis between the two pubic bodies, but occasionally a rudimentary cavity exists in the cartilage, though it seldom has any synovial lining. Occasionally no symphysis pubis exists, a condition constantly met with in ectopia vesicæ (Chapter XX., Vol. II.).

The joint may be disrupted in young adults and children as the result of trauma, whereas fracture of the os pubis will occur in later life as the result of crushes.

Tuberculosis rarely may affect the joint, either as a primary cartilage disease, or more commonly from the pubes; still more uncommonly septic or typhoid osteitis may be met with.

Clinically there is pain and swelling, with possible fluctuation in the neighbourhood of the mons veneris, and care must be taken that the condition is discriminated from superficial abscess or extravasation of urine. An X-ray film should be taken.

Treatment consists in incision and free curettage of diseased tissue, with fixation by a pelvic band and rest in bed.

THE HIP JOINT

This freely mobile ball and socket joint is situate between the os innominatum (acetabulum) and the femoral head, deeply among the muscles of the buttock and thigh, which closely surround it and control its movements. The synovial cavity extends to the acetabular edge and down over the neck of the femur on its posterosuperior aspect, and is reflected on to the tubular ligamentum teres from the cotyloid notch at the lower acetabular lip to the fovea capitis femoris, along which tube twigs from the obturator vessels and nerve pass to form the blood and nerve supply of the epiphysis of the femoral head. The joint is closely surrounded by a very dense capsule, especially marked in the front where it forms the Y-shaped ilio-femoral ligament, beneath which protrudes a pouch of synovial membrane to form the psoas bursa. Owing to its depth from the surface and its dense capsule it is practically impossible to detect any fulness when effusion occurs in the joint, though in some cases the distension of the communicating psoas bursa can be detected as a fulness in Scarpa's triangle deep to the femoral vessels, which may be displaced slightly inwards, the condition being more noticeable in thin subjects; the joint, however, assumes characteristically its position of greatest capacity under these circumstances, *i.e.*, eversion, external rotation and some flexion, while owing to the tense capsule limiting effusion, movements are markedly restricted and painful.

Pain, which is marked, is often referred along the course of the nerves supplying the joint, and thus may be complained of in the knee, a condition known as referred pain, where its situation may be very helpful in indicating the position of the disease in the hip joint, on account of the following facts:—

1. The obturator nerve, as already pointed out, supplies the femoral head

via the ligamentum teres; it also supplies the back of the knee joint and crucial ligaments *via* its geniculate branch.

2. The acetabulum is supplied by certain branches of the sacral plexus which are closely allied with the sciatic nerve, the popliteal branches of which supply the back and sides of the knee joint, the articular cartilages of the femur and tibia and the ligamentum mucosum.

3. The anterior crural nerve, *via* its branch to the rectus femoris, supplies the synovial membrane of the joint, and also *via* the patellar and subsartorial plexuses the synovial membrane of the subcrureal bursa and pouch and the patella.

Hence if the hip disease is in the femoral head, pain is referred to the centre of the back of the knee, and if in the acetabulum, to the articular surfaces and beneath the patella and deeply in the joint, while if the infection in the hip joint is synovial, pain is referred to the inner side of the thigh, suprapatellar pouch and surface of the patella.

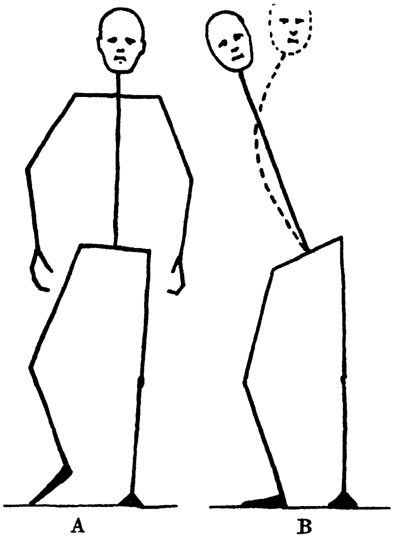


FIG. 325. Diagrams to show (A) primary, (B) secondary, deformities in the first stage of hip disease.

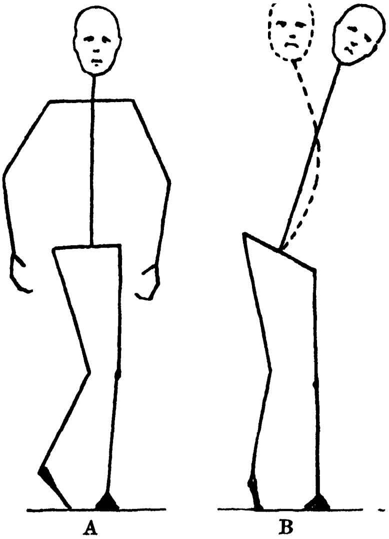


FIG. 326. Diagrams to show (A) primary, (B) compensatory, deformities in the second stage of hip disease.

Infections of the Hip Joint fall into two classes pathologically, according as the primary infection is (*a*) synovial, or (*b*) osseous, conditions which may be ascertained frequently by careful attention to the situation of the referred pain and from a careful study of X-ray films ; but it must be remembered that effusion into the synovial membrane will occur from adjacent bone disease (Chapter XVIII.), so that from a clinical point of view the early stages of both synovial and osseous disease will give the same clinical appearances, while in the later stages bone will be involved in primarily synovial cases and vice versa ; it follows, therefore, that such a pathological classification of hip disease is of little practical value, although an attempt should be made to establish the primary seat of disease in all cases, as the prognosis is always better in synovial infections as regards subsequent joint movements.

A useful clinical test is to make the patient turn over, when if active bone or cartilage disease is present he always turns on the sound side, whereas in synovial or old disease he will turn on either side indifferently.

It is usual to divide diseases of the hip joint into (1) acute and (2) chronic, and to describe various stages of the condition according to the progress of the disease, irrespective of the ætiological factor.

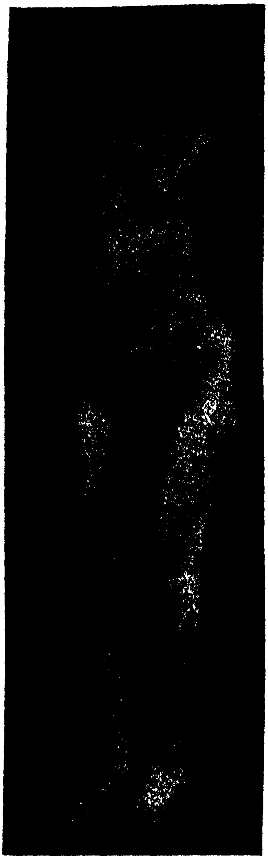


FIG. 327. Tuberculosis of the left hip, showing adduction and dorsal dislocation with real shortening, flexion and lordosis. Note wasting of the left thigh.

Three stages of hip disease are usually recognised, but it must be realised clearly that certain synovial infections, as rheumatism and hæmophilia, seldom pass beyond the first stage, while bone infections, septic or tuberculous, pass progressively through all the stages more or less rapidly according to the virulence of the infection. In each stage there is a primary deformity due to contortion at the hip joint, accompanied by secondary deformities: (*a*) firstly, tilting of the pelvis, which is tilted so as to bring the sound limb parallel with the diseased one in such a position as to permit of walking; (*b*) secondly, spinal curvature to re-establish the trunk and eyes on a horizontal level so as to permit normal vision, these secondary deformities, of course, varying in type according to the primary deformity present.

(1) **The First Stage** is that of effusion into the joint which assumes the position of greatest capacity, the *primary deformity* being flexion, abduction and eversion of the hip, and consequently of the whole lower extremity. The *secondary pelvic deformity* consists in tilting of the pelvis down towards the affected side to compensate the abduction, wherefore the limb looks apparently longer than the sound one, and rotation forward at the sacroiliac joint to correct the flexion; the *spinal compensation* consists in a dorsilumbar lateral curvature, with the convexity to the affected side to keep the horizontal axis, and forward curvature of the lumbar spine (lordosis) to conceal the flexion of the hip and permit balance in walking. This stage is often known as the *stage of apparent lengthening.*

(2) **The Second Stage** supervenes when the articular cartilage becomes diseased, and coincides with the onset of "starting pains" (Chapter XVIII., p. 601). In order to prevent movement of the diseased cartilages on each other, reflex spasm occurs in all the muscles around the joint, which assumes such a position as it is pulled into by the strongest group, in the case of the hip the adductors, internal rotators and flexors, largely the iliopsoas. The *primary deformity* is therefore adduction, flexion and internal rotation of the limb; while *secondary deformity* consists in tilting of the pelvis up on the affected side with the result that the limb appears shortened, and persistence of the rotation forwards, the spinal lordosis persisting also to correct this, while the lateral curvature reverses, *i.e.*, the convexity is to the sound side. This stage is often called that of *apparent shortening.*

(3) **The Third Stage** results when destruction of intra-articular ligaments and the joint capsule, or when absorption or destruction of the femoral head or acetabulum permit the spastic muscles to drag the disorganised joint from its normal relationships, with consequent pathological dislocation of the femoral head in the direction of the pull of the strongest muscles; so the position of the limb is maintained as in the second stage, *i.e.*, adduction, flexion, and inversion, only more exaggerated. But now actual shortening results from upward displacement of the femur on the ilium, *i.e.*, consequent on dorsal dislocation of the joint, where in very chronic cases a pseudarthrosis may be formed. Secondary deformities are as in the second stage, only they are more exaggerated and tend to become permanent, *i.e.*, the pelvis is tilted up on the affected side and forwards, with spinal lordosis and curvature which is convex to sound side.

This stage is spoken of as that of *real shortening*.

Throughout all the stages, but more markedly in the later ones and in chronic cases, all the signs of joint disease described in Chapter XVIII. will be detected in the surrounding tissues. There will be marked loss of tone and, in the second and third stages, wasting and spasm of the thigh and buttock muscles, the buttock appearing flattened and the gluteal fold on the affected side being reduced or absent owing to the flexion at the hip. In the third stage the displaced and deformed femoral head usually can be palpated easily on the ilium deep to the wasted glutei. In the later stages *abscess* may be detected frequently by swelling and fluctuation in the region of the joint; it may point either in the gluteal region behind the trochanter or in Scarpa's triangle, and even into the pelvis, being detected per rectum. Sinus formation may follow evacuation of these abscesses, with the formation of a fæcal fistula if the bowel is involved.

Pain is usually persistent, and as already stated (p. 622) is often referred to the knee, which will, however, be found normal on examination; and persistent pain in a knee which is healthy always should lead to careful clinical and X-ray examination of the hip.

Clinical Examination of the Hip Joint to ascertain the stage and ætiology of the disease must be carried out in a good light, with the patient completely naked, so as to ensure accurate comparison with the sound side and a complete and thorough view of the whole area.

The condition of the muscles and type of gait must be noted; in disease and injury of this joint the patient will bear more weight on the sound limb and limp on walking, dipping to the sound side, whereas in congenital displacement the patient dips to the affected side (Chapter XXI., p. 677), as also in sacroiliac disease.

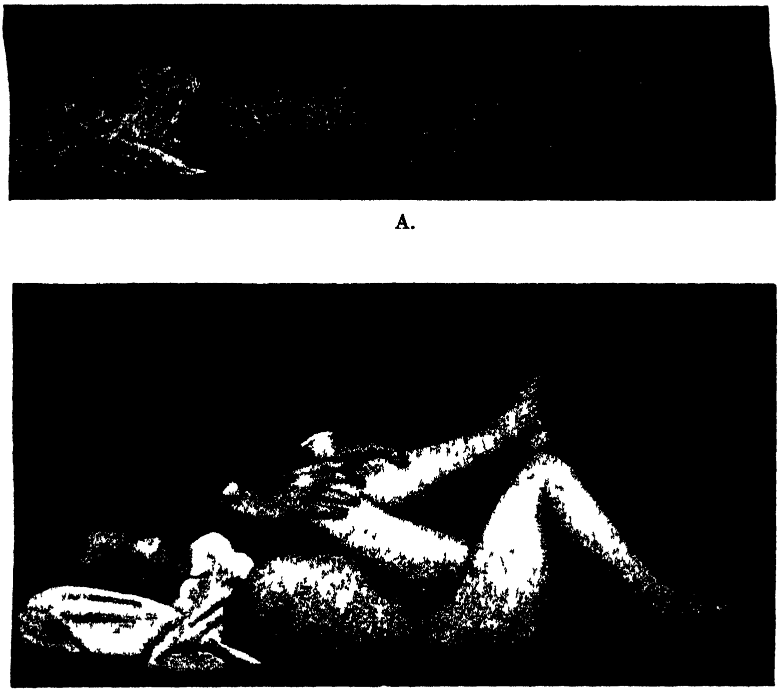
The actual position of the limb relative to the pelvis and trunk must be established carefully, with regard to which it must be remembered that the secondary pelvic and spinal deformities tend to conceal the true position of the joint.

The patient should lie on the back on a firm couch with the limbs extended and any deformity be noted.

1. *Abduction or adduction* may be obvious, but may be concealed by tilting of the pelvis; so the relative position of the anterior-superior iliac spines should be noted and marked, and the legs placed in such a position that the line joining the anterior-superior spines is at right angles to the long axis of the body. To measure for *apparent differences in length,* the end of the measure is placed on the umbilicus or symphysis pubis, and the measurement

taken to the tip of each internal malleolus, when any apparent difference in length due to pelvic tilting will be recorded, *i.e.*, in the first and second stages of hip disease.

To measure for *real difference in length* of the lower extremities, the measurement is taken from the anterior-superior spine to the tip of the internal malleolus on each side, any difference there being due to real shortening of the limb. In order to localise the portion of the limb in which the shortening is: (*a*) If it is in the leg, the measurements from the top of the patella to the internal malleolus will be different on the two sides.


A.

B.

FIG. 328. Child with tuberculosis (late) of the right hip. A. Showing flexion and compensatory lordosis. B. Showing how full flexion of the sound left hip obliterates the lordosis and shows the true amount of flexion present in the diseased right hip. (After Warren.)

(*b*) If it is in the thigh, then the measurements from the anterior-superior spine to the top of the patella will be different; if this is the case, as it will be in hip disease (third stage), the next step is to ascertain if the shortening is in the shaft of the femur or due to either destruction or displacement of the head and neck of the bone (as is the case in the third stage), which can be ascertained sometimes by seeing that the trochanter major on the affected side is on a higher level in the latter contingency.

In many cases, however, this raising of the level of the trochanter in shortening due to disease and displacement of the femoral head and neck (see also Dislocations, Chapter XVII, p 489) can be ascertained only by careful measurements, to which end full use must be made of:—

(*a*) *Nelaton's line,* which is drawn from the anterior-superior spine to the most prominent part of the tuber ischii, and just passes through the tip of the great trochanter if this is in its normal position.

(*b*) *Bryant's triangle*, a more accurate method, where a perpendicular is dropped from the anterior-superior spine to the bed on each side, and the distance from this to the top of the trochanter measured at right angles on each hip; the third side consists in a line from the spine to the tip of the great trochanter and serves by its relative length to show if the trochanter is rotated or displaced forward or backward (see also p. 483).

2. *Flexion* may be masked by lordosis, which can be detected either (*a*) by passing the hand under the lumbar spine, which can be felt unduly arched; if the diseased hip is then flexed up till the lumbar spine can be felt to be in contact with the couch, the amount of flexion required will be a rough measure of the actual flexion present; or (*b*) better, by fully flexing the sound hip on the abdomen, when the lordosis is obliterated and the diseased hip assumes its true flexed position, the angle of which should be estimated.

3. *Inversion and eversion* can be detected by noting the direction in which the foot points when the limb is at rest.

It must be remembered that *limitation of movements* at the hip joint can be and is masked very effectively by increased movement at the sacroiliac joint (p. 620) and also of the pelvis and lumbar spine, so that in testing passive movements the anterior-superior spine must be held under the one hand, while the other moves the limb; the spine then can be felt to rotate so soon as the limit of the true hip movement is reached, a position which must be carefully noted and compared with that at the sound joint.

Similar precautions in "fixing the pelvis" must be observed in testing active movements, where again too much stress cannot be laid on the importance of comparing the range of movement at the diseased hip with that on the sound side.

ACUTE INFECTIONS OF THE HIP

(*a*) **Pyogenic infection** secondary to acute septic osteitis (Chapter XVIII., p. 534) of either the femoral diaphysis at the head or of the acetabulum is by no means uncommon in children and young adults, but is rarely seen after twenty.

The onset is usually acute, with severe pain and toxæmia, and may follow on a septic osteitis elsewhere in the body, or be a sequel to scarlet fever (scarlatinal hip), but is often primary. The limb is held immobile in a flexed, abducted and everted position, and the muscles are in a state of spasm, in order to prevent movement of the joint; this process produces great pain, of which the patient is so acutely apprehensive that any attempt provokes loud screams. There may be fulness in Scarpa's triangle, where also redness, œdema and local increase of temperature may be detected. The cartilage and bone become rapidly involved, and the joint assumes the signs and position of the second and third stages of hip disease.

(*b*) In some cases, especially the *post-scarlatinal* ones, the onset is much more insidious and would often appear to be a primary synovial infection, nothing being complained of but a little local discomfort; this may indeed be absent, so that only the detection of deformity such as broadening of the hips and raising of the trochanter, or inability of the patient to use the limb on leaving bed, will lead to a suspicion of a pathological dislocation.

Pathological dislocation, usually of the dorsal type, is an early and frequent complication of both forms of the disease, consequent on softening and destruction of ligaments, with disorganisation of the joint, the bones being pulled upon by the spastic muscles. It can be detected by finding the trochanter raised, the limb shortened, adducted and internally rotated (Chapter XIX., p. 625), and should, of course, be confirmed by X-ray photographs.

Abscess formation is, naturally, a constant accompaniment of pyogenic infection, the pus being at first confined to the joint cavity (pyarthrus), but soon passing out among the surrounding muscles, among which it burrows extensively along the fascial planes, until it reaches the surface, where it presents usually behind the great trochanter. So long as the pus is confined to the joint severe and agonising pain of a throbbing character is present, which is aggravated by the ulceration of the articular cartilages ; these become pressed together by the spastic muscles and give rise to severe pain on any attempt at movement ; once the pus has escaped into the surrounding tissues pain is less owing to relief of tension, and toxæmia is temporarily less marked.

Ankylosis of the joint invariably follows if the patient survives the acute stages, and is both true and false (Chapter XIX., p. 589) ; the true ankylosis is usually bony in type, the joint being fixed in a position of adduction, flexion and inversion, with the head lying on the dorsum ilii, and the limb considerably shortened, as in the third stage of hip disease, a deformity which precludes walking as a " scissor leg " is present.

The *treatment* consists in early recognition of septic osteitis and prompt operative treatment (Chapter XVIII., p. 541) to prevent joint infection. Once pus has gained access to the synovial cavity and in primary synovial cases treatment must be undertaken immediately on the lines laid down (Chapter XIX., p. 593), by immobilisation with extension ; the limb is held in a position of abduction and slight flexion by means of a Thomas's splint, while the sound limb and pelvis are fixed to the side of the bed so that the patient cannot move over and adduct the abducted diseased joint, which also needs fixation of its splint. Should this treatment not suffice the joint must be opened, the best approach being from behind (Chapter XXII., p. 727), and washed out ; the synovial cavity is closed and a drainage tube left down to it, the limb, of course, remaining on the extension splint. Aspiration is both dangerous and unsatisfactory owing to the depth and nature of the joint.

In very toxic cases amputation through the hip joint may be considered (Chapter XXII., p. 722), but the chances of recovery are very small, and such a desperate remedy should only be applied after due consultation.

Abscesses in the surrounding tissues need incision and drainage, the pus should be cultured, and subsequently vaccines may be useful should pyæmia supervene, a by no means uncommon occurrence. Sinuses should be examined for the " button " granulation at the mouth, so characteristic of dead bone, and an X-ray picture be taken to locate sequestra and carious areas, when the former need removal and the latter free curetting with a sharp spoon.

Pathological dislocation can be prevented by early extension and splintage, but here a word of warning against undue extension is not amiss, as this will sometimes disrupt the softened ligaments and cause an obturator dislocation, with undue lengthening of the limb which is abducted and flexed. Should any dislocation have occurred the head must be manipulated back into the acetabulum (Chapter XXV., p. 678) and the limb be fixed in an extension splint in abduction to about 45 degrees to 60 degrees, or so held in a plaster of Paris spica.

In old-standing cases, where the head is ankylosed on the dorsum ilii, and the limb flexed and adducted, thus causing pain and disability in walking, osteotomy (better Gant's sub-trochanteric, but sometimes Adams', Chapter XXI., p. 716) must be performed; the limb is fixed in plaster in abduction for three months, and then a walking caliper is fitted for another six. After this a high boot will be required.

Diagnosis. Various forms of trauma, *i.e.*, fractures and dislocations (Chapter XVII.), may give rise to difficulty unless X-ray films are taken as a routine in all cases.

Differentiation from other forms of hip disease is usually easy, as none give such severe signs of toxæmia, though occasionally *typhoid* or *pneumococcal disease* may give rise to errors in diagnosis, while more rarely still *gonococcal fibrositis* or arthritis may closely simulate septic infection ; but here a primary focus is present and infection in the hip joint rare.

Acute rheumatism and *dysenteric synovitis* are acute in onset, but never go beyond the synovial stage, and other joints are usually affected.

Tuberculous osteitis may suddenly burst into and infect the joint, " acute tuberculosis," but there are always marked muscle wasting and a history of pain previous to the acute onset. The X-ray film is helpful.

The acute onset of a *Charcot's joint* may give rise to error in diagnosis, but the lack of signs of infection, the normal temperature and solid œdema, combined with other signs of tabes and the X-ray appearances, clear up the diagnosis easily ; this is more than can be said for those cases where septic infection supervenes on a Charcot's joint, a condition of grave import and usually calling for amputation (Chapter XIX., p. 617). Separated epiphyses in syphilitic babies are a potent source of error, when they occur. From infection of the sacroiliac joint and great trochanter, hip disease, as already noted (Chapter XX., p. 621), can be differentiated by careful examination, when it will be found that the joint movements are normal.

It must be remembered with regard to X-ray examination that so long as the disease in any joint is purely synovial no abnormality can be seen on the film.

In abscesses near the joint great difficulty may be experienced in determining whether pus around the hip joint has involved the synovial cavity ; X-ray films may be helpful, but often only close investigation of clinical signs, and especially joint movements and pain, will clear up the point.

Typhoid Arthritis occurs occasionally, usually secondary to osteitis in the femoral head, during the later stages of typhoid ; the onset is often insidious, and owing to the serious condition of the patient liable to be overlooked till dislocation occurs.

The signs and treatment are the same as for septic arthritis of the hip, and as laid down in Chapter XIX., p. 598.

Pneumococcal Arthritis is occasionally met with in children, and rarely in adults with pneumonia ; the onset is sudden, and the condition closely resembles that seen in septic arthritis ; treatment is as for that condition and as laid down in Chapter XIX., p. 595.

Influenzal and Dysenteric Synovitis both occur rarely and may be bilateral ; they call for no special comment.

Gonococcal Arthritis of the hip is not very common, but may occur as in any other joint, either as a primary pyogenic synovitis or secondary to an adjacent fibrofasciitis (Chapter XIII., p. 596).

The onset is very sudden and the pain and disability, at first severe, tend to improve up to a point ; the condition then becomes stationary and is often treated as sciatica. Gonorrhœa is, however, always present, though often in the chronic stage (Chapter VI.).

The hip becomes distended and painful, there is great stiffness in the thigh and buttock, and the lower limb is everted and abducted. Suppuration may supervene; rarely cartilage may be invaded, and the second stage of hip disease supervene.

The *treatment* consists in prompt splintage and extension of the limb in abduction; should suppuration occur drainage will be necessary (p. 595). It should be remembered that fibrous ankylosis, both true and false, invariably follows, and bony ankylosis in those few cases where cartilage is eroded, so that care must be taken to splint the limb efficiently in the position of three or flexion 10 degrees, abduction 45 to 60 degrees, and to keep it there four months, best in plaster of Paris, so as to prevent adduction occurring.

Acute Rheumatic Synovitis is often seen, especially in children, and may give rise to difficulty in diagnosis, more often from tuberculous synovitis, but occasionally from suppurative infections. The sudden onset, often with no pain in other joints, is most deceptive, but a furred brown tongue and acrid sweat will help to clear up the diagnosis, which can be confirmed by the administration of four-hourly doses, grs. v to x, of aspirin, a drug to which the rheumatic condition rapidly yields.

The limb, of course, never passes beyond the stage of apparent lengthening, as the disease is purely synovial.

Hæmophiliac Hæmorrhages may occur in and around the hip joint in boys and adults suffering from the disease, causing a swollen, painful, hot hip, which is abducted, flexed and everted, there being, however, little or no muscular rigidity. Unless a careful history be taken the presence of hæmophilia may not be elicited, when suppurative rheumatic or tuberculous disease may be diagnosed.

Treatment, of course, consists essentially in rest, any form of operation being rapidly fatal from hæmorrhage.

Similar hæmorrhages may be met with in and around the hip joint in any blood disease, notably scurvy, and in severe septicæmias.

CHRONIC HIP DISEASE

This may be septic as in chronic pyæmia, but is most frequently due to one of three conditions:—

(*a*) Tuberculosis—much the most common in children and young adults.

(*b*) Osteoarthritis—common in elderly people.

(*c*) Charcot's disease—usually associated with tabes dorsalis.

Rarely other chronic conditions are met with, notable among which is **Gummatous Synovitis**, which is occasionally met with in syphilitic subjects, when it closely resembles tuberculosis in its signs, save that it tends to be bilateral, abscess formation is early, and pain and muscle wasting not nearly so marked.

Its treatment is as for tuberculosis, with administration of antisyphilitic remedies and potassium iodide (Chapter VI., p. 121).

Tuberculous Hip (Morbus Coxæ) is far more common in childhood than in adult life, and is undoubtedly the condition of the joint which the surgeon is most often called on to treat, and one which, owing to careless examination, he is all too prone to overlook in those early stages when cure with a movable joint may be hoped for.

(*a*) *Osseous type.* The joint disease is most often due to infection in the ileum at the upper surface of the acetabulum, as can be shown by routine X-ray examination; it may be secondary to tuberculous osteitis and abscess in the femoral head (Chapter XVIII., p. 547), but in some cases a primary synovial infection is present, the progress of which is slower and the prognosis correspondingly better than in the bony type ; it is of interest, therefore, to determine in the early stage which variety is present, but it must be realised clearly that in both types cartilage disease will supervene sooner or later, and when once this is established, *i.e.*, when the second stage is present, no difference in prognosis is to be expected. Caries sicca occasionally occurs in the femoral head.

(*b*) In the *synovial type* the onset is very insidious and painless, the stage of abduction, eversion and flexion lasting for a longer period (up to three months) and the muscle spasm and wasting being less than in the osseous type. The X-ray film is completely negative, whereas in the osseous type bone changes, caries and abscess cavities can be seen in the femoral head and neck or in the acetabulum.

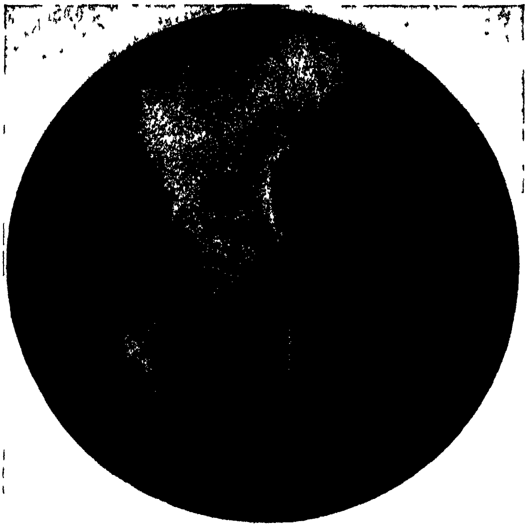


FIG. 329. X-ray film showing caries of the head of the femur and acetabulum in early hip tuberculosis.

As already pointed out (p. 622), pain referred down the front of the thigh and to the suprapatellar pouch strongly suggests synovial disease only, whereas pain at the back of the knee or below the patella favours osseous infection.

On examining the child it should be asked to turn over on the couch several times, when, if osseous disease be present, it turns persistently on the sound side, whereas if there is a pure synovial infection it will turn on either side indifferently. This sign, as will be pointed out, is of value in the later stages in differentiating if active disease be present, or ankylosis or Perthe's disease (p. 551).

The clinical signs, whichever type be present, are those most classically seen in hip disease, the joint passing progressively through the stages (p. 623) of :—

1. Synovial effusion with apparent lengthening, while either pure synovial infection is present or the focus is confined to the bone and causing effusion.

2. Cartilage infection with apparent shortening.
3. Disorganisation with real shortening.

Muscle wasting is early and very marked in tuberculous disease, a point useful in differential diagnosis, while of course loss of muscle tone is present, even before wasting is obvious. Spasm, with consequent limitation of all movements, is noticeable in the first stage, but becomes much more obvious in the second, where the joint is held rigidly fixed, any attempt at movement being very painful; this is seen in the classical "starting pains" which occur in the second stage, when the relaxation of the muscles on falling asleep allows the cartilaginous surfaces to move and awakes the patient with a start.

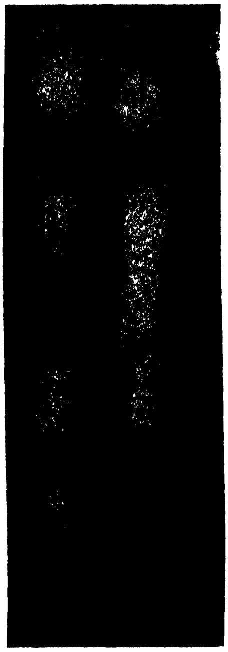


FIG. 330. Early tuberculosis of the left hip, showing flexion and wasting of thigh muscles. *N.B.* difference in the gluteal folds.

The patient's general health is poor, hectic temperature and other signs of tubercle may be present. Later there is abscess formation, usually pointing anteriorly in Scarpa's triangle or in the buttock beneath the gluteus maximus; more rarely it is intrapelvic, when a fæcal fistula may follow rectal involvement, with subsequent sinuses, secondary infection and the onset of amyloid disease; in any case fibrous ankylosis generally occurs. In this respect it must be remembered that bony ankylosis never occurs in tuberculous joints unless sepsis has supervened, usually from sinus infection.

Treatment. This consists essentially in immobolising the joint in a plaster of Paris splinting, fixing the pelvis and both lower limbs (Chapter XIV., p. 417) in a position of abduction and extension, in which casing they must be kept for at least three months after cessation of all signs of active disease as shown by X-ray photographs (p. 602); after this a walking caliper should be worn, when not in bed, for six months.

In cases of the synovial type, where the patient can be kept under observation, and especially if sun or ultra-violet treatment be regularly available, sufficient fixation and extension can be secured by a walking caliper, which permits of the sun reaching the bare skin, and also of mobility.

Abscesses should be aspirated, and usually settle down if this treatment and rest be combined. As already indicated (Chapter XVIII., p. 547), if an early case of tuberculous osteitis, where the lesion is still confined to the bone, does not settle with rest, then it is advisable to operate and evacuate the abscess rather than risk its bursting into the joint. Sinuses need curetting and sequestra removing.

Ankylosis is fibrous, and no attempt should be made to break it down, as such a proceeding often liberates encapsuled bacilli and restarts the disease. Adduction and flexion can be corrected by Gant's subtrochanteric osteotomy and shortening by a high boot.

Differential Diagnosis. (*a*) *First stage, synovial infection.*

The differential points in the first stage between the synovial and osseous types have already been discussed.

Rheumatic synovitis is a fruitful source of error in children, where the sudden onset is often mistaken for the "acute tubercle" stage seen when the bone abscess first bursts into and infects the synovial cavity. The presence of acrid sweats, infection of other joints, and cardiac signs are all seen in rheumatism, with absence of the wasting seen so early in tuberculous cases. In cases of osseous tuberculosis X-ray films will establish the diagnosis beyond all doubt, but if synovial infection is suspected, then observation under rest and aspirin may be necessary to clear up the diagnosis.

Sacroiliac disease, as already pointed out (p. 621), is a source of error in diagnosis, though this condition is uncommon in small children, and careful examination will show the hip movements to be normal. X-ray films reveal caries at the sacroiliac junction.

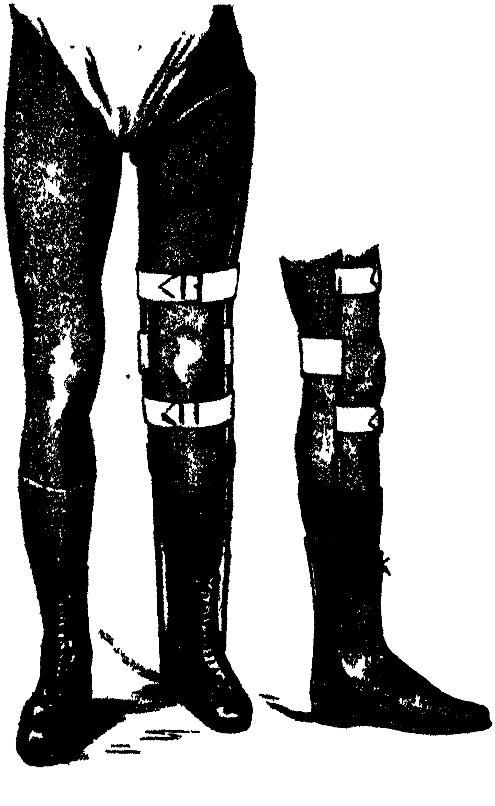


FIG. 331. Walking caliper splint. Note the heel clear of the boot.

Gummatous synovitis is very rarely seen, but when present closely resembles tuberculosis, and can be diagnosed only if a positive Wassermann is obtained. In the bony type osteosclerosis, with possibly separation of the epiphysis, may be detected on X-ray examination.

Traumatic, hæmophiliac or scorbutic, dysenteric, etc., effusions may give rise to errors in diagnosis if a careful history is not taken and thorough examination is not made, but here again absence of marked wasting practically excludes tuberculosis.

(*b*) *Second stage, cartilage disease*, with marked spasm.

As already noted, in the majority of bone cases tuberculosis starts in the upper part of the acetabulum, so the synovial membrane becomes infected earlier around this and the upper part of the head of the femur, the articular cartilage of which is eroded sooner, therefore, with enlargement upwards of the acetabulum, which becomes eroded early and enlarged by caries of the underlying bone.

The acetabular type should be suspected when the second stage advances rapidly, when the muscle spasm is less marked than usual, and shortening can be detected early in the second stage; an X-ray film shows the head to be in the socket, but the acetabulum enlarged. This variety is liable to escape notice in the X-ray film as the femoral head is healthy and the acetabular caries and enlargement are not noticeable unless the sound joint is photographed for comparison. This is the variety of disease which develops intrapelvic abscesses, with subsequent fæcal fistulæ.

(*c*) *Third stage, ankylosis of the dislocated and disorganised joint.*

The late stages, with ankylosis and shortening, may occur not only in tuberculosis, where fibrous ankylosis is always present unless sinuses and secondary infection have supervened, but also in osteoarthritis, from locking of osteophytes, and Charcot's disease in advanced cases, in which it is rare, however; in addition it is seen after acute septic, scarlatinal or pyæmic infections, when bony ankylosis is the rule, and gonorrhœal arthritis, where either type of ankylosis may exist. An X-ray film, of course, will establish if the ankylosis is fibrous or bony in type, and a careful inquiry into the history will probably elicit the nature of the original disease, should physical signs indicative of its nature not exist.

Treatment will vary with the cause of the condition, but must aim at correcting the deformity, usually adduction and flexion, so as to permit walking, and if possible at establishing a movable articulation by some form of arthroplasty or Adams' osteotomy, with a fascial implant.

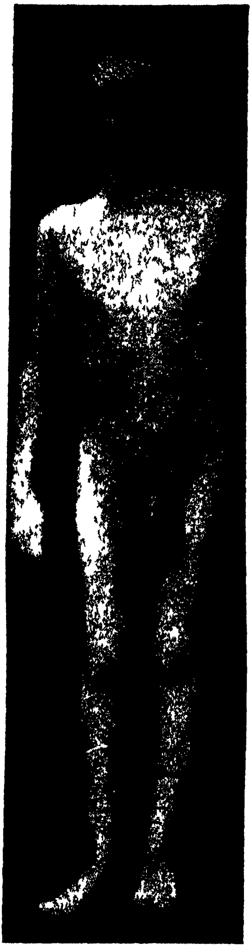


FIG. 332. Tuberculosis of the hip (third stage), showing flexion and real shortening.

In many cases it is inadvisable to interfere with the joint, as such a proceeding is liable to reawaken the disease, and in these cases a Gant's subtrochanteric osteotomy is of use; all tuberculous and gonococcal cases are best treated on these lines.

In some few cases, where fibrous ankylosis is present, the treatment advocated in traumatic ankylosis, namely wrenching under anæsthesia, is justifiable, but it is always very liable to cause recrudescence of the disease and should be employed with great caution.

Osteoarthritis (Morbus Coxæ Senilis) is a condition met with only in adults, and usually those of advanced years; thus diagnosis is mainly from senile tuberculosis, and never need give rise to any doubt in hip disease in childhood.

The condition is very common, especially in manual labourers, and

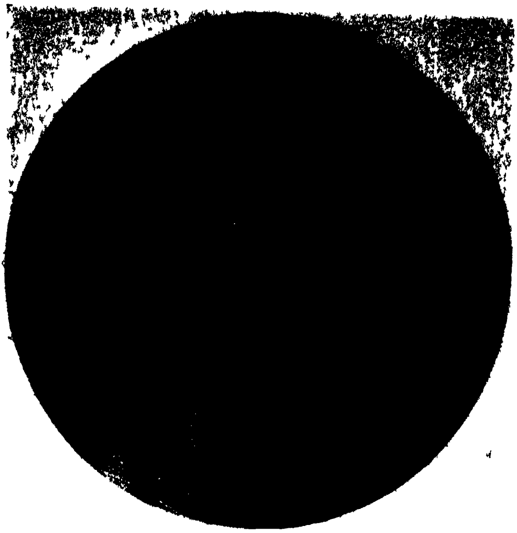


FIG. 333. X-ray film showing destruction of the femoral head and ankylosis in advanced tuberculosis.

usually is of the monarticular type (Chapter XIX., p. 609), with marked bony changes; not infrequently several other joints are involved and will present similar symptoms.

In the monarticular cases a history of definite trauma is often elicited as occurring shortly before the onset of symptoms, and injury would appear undoubtedly to predispose to localisation of the toxæmia in these cases.

The onset is insidious, with gradually increasing pain and impairment of mobility in the joint, which following on degenerative changes in the articular cartilage (Chapter XIX., p. 611) assumes a position of adduction and flexion owing to muscle spasm; consequent upon the absorption of the softened cartilage and bone at the pressure points, true shortening manifests itself very early and increases steadily in amount till 2 or 3 inches may be demonstrated in severe cases.

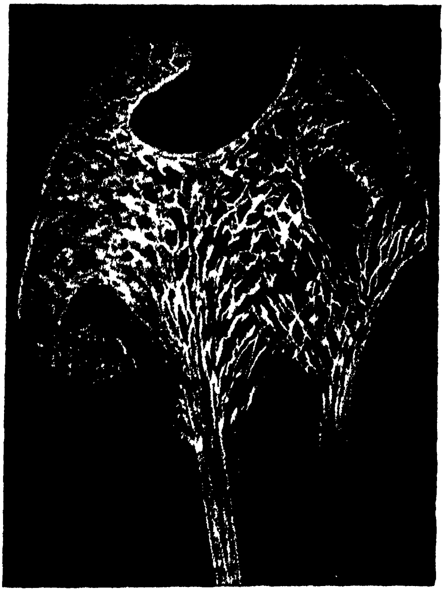


FIG. 334. Morbus coxæ senilis, showing mushrooming of the femoral head.

The pain may be very severe, especially early in the day, but, unlike pain in tuberculosis or inflammatory lesions, tends to improve as the joint is moved and used.

The muscles around the joint show considerable loss of tone and in late cases wasting, but this is not so marked in the early stages as in tuberculosis. Adductor spasm is very marked, and in old-standing cases permanent shortening and fibrosis of the flexors and adductors cause a fixed deformity of the joint, so that the patient's body is doubled forward at the hips. Movements at the joint are limited, especially abduction, and accompanied by coarse creaking and grating which may be audible, but always can be appreciated by placing the hand over the region of the joint.

Fibrillary twitching in the quadriceps or hamstrings is strongly suggestive of osteoarthritis as against tuberculosis in the hip.

Owing to the degenerative softening in the bone and cartilage, rapid absorption of the femoral head, especially its upper and inner parts and those surfaces of the acetabulum with which it is in contact, leads to flattening and gradual disappearance of the head and neck of the femur, and deepening and extension of the acetabular cavity, which moves up on to the ilium (*travelling acetabulum*). These changes are manifested clinically by a steadily increasing shortening of the limb, the great trochanter rising in direct ratio, and at the same time getting nearer the midline, as can be demonstrated by measurement from the symphysis pubis to the trochanter on each side and the mechanical obstruction met with on attempted abduction of the hip.

As softening of ligaments also occurs, actual dorsal dislocation from pull of the spastic muscles is not uncommon in the later stages, when the deformed femoral head can be felt on the dorsum ilii deep to the wasted gluteal muscles.

Considerable lipping (p. 611) occurs at the edges of the acetabulum and femoral head, so that the latter assumes the characteristic "*mushroom*" *shape* seen in osteoarthritis of this joint; while in some cases large masses of new bone cause marked prominence and deformity and mechanically obstruct movements, when the condition well merits the name "arthritis deformans" which is applied to it.

Synovial effusion and Baker's cysts are frequently present.

The *treatment* in osteoarthritis of the hip consists in treating pain and symptoms by hot-air baths, counter-irritation, and spa treatment as advised on p. 612; shortening of the limb being compensated by a high boot.

In monarticular cases in robust individuals, especially if much pain and deformity exist, great benefit can be derived by either arthroplasty, as advised by Albee and Robert Jones, or excision with fixation of the limb in slight flexion and abduction as practised by Max Page; but both these operations entail some weeks in bed, and should not be attempted in feeble patients or where other joints are involved.

Hysterical Hip may give rise to considerable difficulty of diagnosis, especially in the instances occasionally met with in children, and can be diagnosed only in most cases after careful examination has excluded all organic disease. There is usually no marked wasting, and attempts at movement are actively resisted by general increase of all muscle spasm. Hyperæsthesia or anæsthesia may be present, and the limb be held in any position, which may vary at different times.

Treatment has been discussed in Chapter XIX., p. 619.

Charcot's Disease is met with commonly in males with tabes dorsalis, and is not uncommonly bilateral; the condition is, however, by no means frequent, the hypertrophic variety being more often seen than the atrophic.

Marked deformity is usually present with dorsal dislocation, the limb being flexed, adducted and shortened; there is great instability of the joint, in spite of which the patient usually staggers in with a shuffling gait and a cheery smile on the lower part of the face, oddly contrasting with the furrowed, frowning forehead (Chapter XIX., p. 616).

In some cases the onset is apparently sudden, and marked œdema of the limb may be present.

Pain and muscle spasm are markedly absent, though "lightning pains" are frequently present and may lead to some confusion unless the nature of the pain is elicited. Other signs of tabes, such as absence of jerks, and skin sensation, and the presence of Argyll Robertson pupils, will clinch the diagnosis. The condition is most likely to be confused with arthritis deformans unless a careful examination is made, but in bilateral cases the waddling gait may lead to a diagnosis of congenital dislocated hips though this is practically only met with in women, and of course will have existed from early childhood.

The *treatment* consists in the application of some *light* splint, such as a walking caliper, to ensure stability of the joint, but the apparatus must be neither heavy nor cumbersome or it cannot be borne by the ataxic patient. General antisyphilitic treatment should be carried out.

Congenital Dislocation of the Hip, seen almost entirely in female children, should give rise to no difficulty in diagnosis, as the patient if able to walk dips characteristically to the affected side, and in younger cases the shortening can be diminished by traction of the limb. There is no muscle wasting, spasm is limited to the adductors, and pain is absent (see Chapter XXI., p. 675).

Coxa Vara (Chapter XXI., p. 679), usually seen in adolescents after slight injury to the hip, or in rachitic children, should cause no trouble in diagnosis, as adduction with external rotation and real shortening is pathognomonic of this condition.

THE KNEE JOINT

The knee joint is the most superficial and easily palpable joint in the body, and hence, although liable to trauma and infections, its condition can be easily and early diagnosed. The joint is a nearly pure hinge between the femoral and tibial condyles, though some slight rotation takes place between the inner condyles during flexion and extension.

The capsule is strengthened in front by the presence of the patella, quadriceps expansion and ligamentum patellæ ; laterally by the iliotibial band, cordlike external lateral ligament, and the tendon of the popliteus muscle ; medially by the broad internal lateral ligament and the close application of the sartorius and tendons of the gracilis and semitendinosus ; posteriorly by the expansion of the semimembranosus insertion, known as the oblique ligament of Winslow, which is applied to the outer aspect of the capsule, and the posterior crucial ligament with the associated slips from the menisci (ligaments of Wrisberg and Humphrey), which are apposed closely to the inner aspect of the capsule between it and the synovial membrane.

It is on the strength of these muscles and ligaments that the stability of the joint much depends, but they are aided by the intra-articular fibrocartilages, the anterior and posterior crucial ligaments, and the internal and external menisci (semilunar cartilages), which materially increase the strength of the joint.

The *medial meniscus* is a strip of fibrocartilage covered on its upper and lower aspects with synovial membrane and presenting a free, concave, sharp edge between the condyles of the femur and tibia, to the edge of which latter, as well as to the internal lateral ligament and joint capsule, this meniscus is firmly attached by the coronary ligaments. The anterior and posterior extremities taper and are attached in front and at the back of the intercondylar space on the tibia, the whole meniscus thus representing a small segment of a large circle, closely adherent at its periphery to the tibia and the joint capsule, and therefore liable to be split away from these attachments if violent rotation occurs between the medial condyles (internal derangement, Chapter XVII., p. 509).

The lateral meniscus is of similar structure to the medial, but is attached at its periphery only to the tibial condyle and not to the capsule, which, as in addition no rotation occurs between the lateral condyles, renders the lateral meniscus much less liable to tearing than the medial. In addition the ends are attached to the front and back of the tibial spine, so that this meniscus presents a large segment of a small circle, its extremities lying embraced between those of the medial meniscus.

The *anterior crucial ligament* is a strong cordlike band passing from the tibial spine to the inner side of the lateral condyle of the femur rather posteriorly and lying behind the synovial membrane which covers its anterior and lateral aspects. The ligament becomes tight in extension, which movement it checks ; it also prevents lateral mobility in the joint.

The posterior crucial ligament arises from the posterior end of the intercondylar notch on the upper and back surface of the tibial head and passes up to the outer side of the internal femoral condyle well forward in the intercondylar notch of the femur, lying behind the synovial membrane, which, however, covers it laterally. The ligament becomes tense in and limits flexion, and also checks lateral mobility of the joint.

Two other intra-articular structures merit notice. The *popliteus tendon* penetrates the outer aspect of the capsule in a sloping direction, passing forwards between the two external lateral ligaments, and reaching up to the femoral condyle, having around it a sleeve-like reflection of synovial membrane. The *ligamentum mucosum* is a tent-like reflection of synovial membrane, with its closed apex in the femoral intercondylar notch and its open base occupied by the subpatellar pad of fat and crossed vertically by the ligamentum patellæ ; this extends between the synovial attachment to the lower edge of the articular facet of the patella above and the transverse ligament on the anterior edge of the head of the tibia below, and ends laterally in two free fringed projections (the ligamenta alaria), which fit in anteriorly between the femoral and tibial condyles and are liable to be pinched in forced extension or hyperextension of the knee, leading to one form of internal derangement.

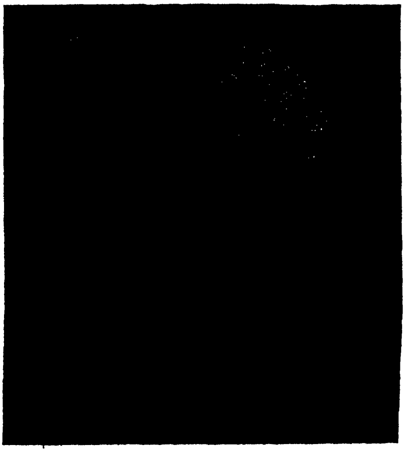


FIG. 335. Effusion in the left knee. Note fulness and absence of the dimple seen on the right side.

The *synovial cavity* is large and complicated, the membrane being reflected below from the edges of the articular facets of the tibia and the transverse ligament, whence it passes, forming, of course, a continuous sheet :—

1. Laterally around the free edges of the menisci and so up the inner aspect of the capsule (being reflected on the outer side around the popliteus tendon, and projecting on the inner side through a slit-like opening as the semi-membranosus bursa), to gain attachment to the lateral and posterior aspects of the femoral condyles about an inch above the articular cartilage, from the edge of which it is reflected down the shaft.

2. Posteriorly the membrane closely embraces the sides and anterior aspects of the crucial ligaments, from which it gains attachment to the articular cartilage of the femoral condyles in the intercondylar notch ; it is continuous at one spot anteriorly with the narrow posterior attachment of the ligamentum mucosum, and laterally with the synovial membrane on the sides of the femoral shaft.

3. Anteriorly from the facets, anterior ends of the menisci and transverse ligament, the membrane passes backwards and upwards, forming a wedge-shaped shelf (ligamentum mucosum), the apex being attached to the intercondylar femoral notch, and the lateral aspect presenting free serrated margins (ligamenta alaria) ; the upper reflection passes forwards to gain attachment to the lower edge of the articular facet of the patella, and beyond this on either side merges into the lateral reflection

on the capsule. The whole passes around the patellar facet, from the upper aspect of which it passes up deep to the crureus (vastus intermedius) for about a hand's breadth above the patella (subcrureal pouch, suprapatellar bursa), whence it is reflected to the anterior aspect of the femoral shaft and so down to the upper edge of the articular facets of the femoral condyles.

From a study of these attachments it will be realised (*a*) that the semi-membranosus, popliteus and subcrureal bursæ are continuous with the synovial cavity of the knee joint (Chapter XIII., p. 399); (*b*) that the base (extrasynovial) of the ligamentum mucosum is closed exteriorly by the lower (nonarticular) part of the patella, ligamentum patellæ and skin, and occupied by the infrapatellar pad of fat, which bulges on either side of the ligament when the joint is extended, the subpatellar bursa, and the inferior articular arteries and nerves, which pass around the tibial condyles to reach it.

In this respect it is well to remember that a diffuse lipoma may occur in this situation and cause the lateral infrapatellar pads to be unduly prominent, a condition occasionally confused with effusion into the joint; or, by rendering the ligamenta alaria unduly enlarged, cause them to be nipped in extension of the joint (one form of internal derangement, Chapter XVII., p. 509).

Other bursæ around the knee joint, such as the prepatellar, subsartorial, etc., never communicate with the synovial cavity, and have been fully discussed (Chapter XIII., p. 400).

Examination of the Knee Joint. When the normal knee joint is examined in either the extended or flexed positions, the patella can be seen forming a distinct rounded prominence in the front of the joint, and having on either side of it a well-marked ovoid sulcus, beyond which the femoral condyle causes a rounded prominence; this depression is bounded below by the prominence of the tibial condyles, and above by the bellies of the vastus externus and internus, the latter being much more prominent and descending to a lower level. On the joint being palpated the patella can be felt resting on the femoral condyles, and no indication can be obtained as to the extent of the suprapatellar pouch, because the synovial membrane, when normal, is not palpable through the quadriceps.

Movements are painless and consist in extension to an angle of 180 degrees, the leg and thigh making a straight line, and flexion till the calf and back of the thigh come in contact; very slight lateral rocking of the tibia on the femur may be present in flexion, but is never possible in extension in a normal knee joint.

In examining always compare the two joints, which should be done in a good light, the patient sitting with the thighs and legs bare and the knee joints semiflexed in the same position. The following points should be noted in all cases:—

1. *Colour and temperature* of the skin (remember a knee that has been bandaged always will be warmer).

2. *The presence of wounds*, septic spots, or other abnormalities in appearance.

3. *Wasting of muscles.* Especially note the rounded, fleshy belly of the vastus medialis (internus) which wastes early and markedly in disease of the knee joint. Remember (*a*) wasting of the quadriceps may be detected by measurement of both thighs at the same level above the patella—6 inches is a good distance, as it clears the upper limit of the suprapatellar pouch, which, if distended, gives a false measurement for wasting; (*b*) loss of muscle tone may be present without wasting, and is shown by flabbiness of the muscle on palpation and loss of the firm, rounded contour seen in the normal limb.

4. *Effusion,* if present, indicates synovial inflammation, and causes a distended appearance of the joint, which is especially noticed (*a*) above the patella, where the distended suprapatellar pouch causes a rounded promi-

nence extending, roughly, 4 inches up beneath the quadriceps; (*b*) at the sides of the patella, where the normal sulcus is obliterated and may even be replaced by a bulging swelling; (*c*) on the inner side of the popliteal space, where a rounded swelling, the distended semimembranosus bursa, may be detected if the narrow neck has not been obliterated by adhesions (Chapter XIII., p. 399).

Remember that a rounded swelling is normally present when the joint is extended, on either side of the patellar ligament, due to the extrasynovial infrapatellar pads of fat in the base of the ligamentum mucosum, and that these may be very prominent in some persons.

Palpation of the joint will elicit two other signs of effusion:—

(*a*) *Patellar Tap.* It will be found that if the fluid be forced into the lower part of the joint by pressing with the hand over the suprapatellar pouch, and then pressure sharply applied to the patella, this bone can be forced back through the fluid on which it floats, and can be both felt and heard to tap on the underlying femoral condyles.

(*b*) Owing to the bulk of fluid, the joint is held in its position of greatest capacity, *i.e.*, semiflexion, so that full extension is limited and painful.

5. *Thickening of the synovial membrane* is almost always present in inflammation, and can be detected by feeling the thickened felt-like membrane, best at its reflexion under the wasted quadriceps at the upper limit of the suprapatellar pouch. Note if the thickening be smooth and uniform or nodular and irregular in distribution.

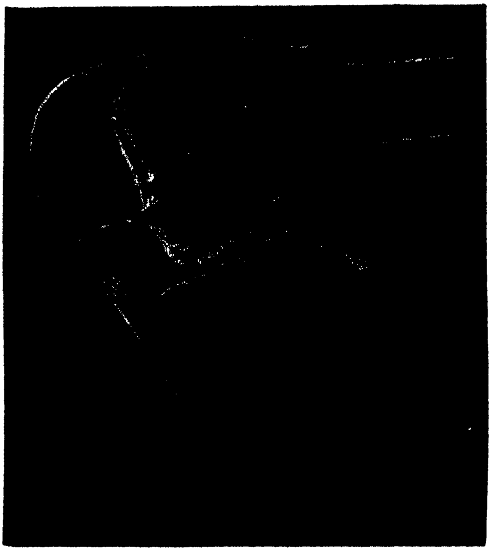


FIG. 336. Triple displacement of the knee joint, with fibrous ankylosis, in old-standing tuberculosis. Note abscess in the end of the femur.

6. *Spasm of the muscles*, if present, always indicates, as in all joint disease, involvement and destruction of articular cartilage, and of course limits all joint movements, attempts to force which cause pain.

7. Should *disorganisation of the joint* have occurred, with destruction of the intra-articular crucial ligaments, etc., then (*a*) lateral movements are possible in extension (as indeed also if the internal lateral ligament has been torn (Chapter XVII., p. 509)); (*b*) in extreme cases ankylosis will have occurred, the joint having been pulled into a position of flexion and external rotation, with the tibia dislocated up behind the femoral condyles, by the hamstrings; this is the so-called *triple displacement of the knee* seen as the late result in all cases of neglected disease (Fig. 336).

Injuries of the Knee. Owing to its exposed position, and its formation, which renders the stability of the joint so much dependent on muscles and ligaments, this joint is particularly liable to (*a*) wounds, (*b*) sprains, and (*c*) internal derangements, *i.e.*, as a result of persistent trauma intra-articular cartilages become loosened, torn or detached, or portions of cartilage or synovial membrane form loose bodies, the presence of any of which causes a chronic synovitis.

While these conditions have been fully discussed in Chapter XVII., p. 509, it is well to remember they are a source of irritation and will cause a synovial inflammation with effusion, which will be hæmorrhagic in acute trauma and serous in chronic instances, but which is always liable to pyogenic infection in cases of wounds or to tuberculosis in chronic cases, both serious conditions in so large and complex a synovial sac as that of the knee joint.

Infections of the Knee Joint. As in any joint, infection may be primarily (*a*) osseous, the more common, (*b*) synovial; but, inasmuch as the synovial reflection occurs beyond both the femoral and tibial epiphyseal lines, bone disease rapidly involves the joint, and as the synovial membrane is large in extent and complicated in arrangement, infection is both extensive and difficult to cope with.

ACUTE INFECTIONS OF THE KNEE JOINT

Pyogenic Infection, as in any other joint, (*a*) may be secondary to (1) suppurative osteitis of the lower end of the femur or upper end of the tibia, the pus spreading to the joint cavity either along the shaft side of the epiphyseal cartilage or, more rarely, through the epiphysis (Chapter XVIII., p. 547), such conditions are nearly always staphylococcal and constitute rather more than 60 per cent. of cases; (2) suppurative infection in the fascial planes and tendon sheaths around the joint, in which case the condition is gonococcal in the vast majority; (3) pyæmic abscess blood-borne from a septic focus elsewhere.

(*b*) Primary infection in the case of (1) wounds involving the joint, or (2) infection of a hæmarthrus from abrasions in the overlying skin, or from the blood stream *via* the circulus vasculosus, is particularly liable to occur in the knee joint, as its superficial exposed position and somewhat insecure bony apposition render it very prone to trauma of all descriptions; also the extent of the synovial lining and intricacy of the joint cavity make resistance to the establishment and spread of infection of very unlikely occurrence, which is of serious import. The synovial membrane appears thickened and felt-like, granulates and bleeds easily, spreading in and destroying the articular cartilage, which also shows areas of softening and destruction at the " pressure points," where the ends of the bones are in contact (Fig. 311).

Clinically in either case all the signs of an acute infection of the joint are present; locally the skin is hot, shiny and tender, and may be reddened or show a wound, while the joint is distended tensely with fluid and the muscles are in a state of spasm, which results in the joint being held semiflexed; later, when the joint is disorganised, triple displacement occurs, with subsequent ankylosis if the patient survives. Pain is acute and all movements apprehensively resisted. In addition the patient is grievously ill, showing all the signs of septicæmia, and is often semiconscious and delirious, the delirium being usually of the low muttering type. In pyæmic joint infection a rigor and sweat often coincide with the appearance of the local signs in the knee. *It must be remembered that an acute prepatellar bursitis, with its pain, redness, swelling, œdema and effusion in the knee joint, closely resembles an acute arthritis of the knee joint.*

Abscess formation, of course, occurs in the joint, usually throughout its whole extent, but occasionally the ligamentum mucosum may localise the infection to the upper or lower parts of the synovial cavity. The nature of the fluid in the knee joint always can be easily demonstrated by aspiration; it is at first usually cloudy or opalescent, but later frankly purulent. In neglected cases the pus may burst under the skin and point, usually on one side of the patella, leading to the formation of a sinus communicating with the joint, a condition seldom seen nowadays, but which, if present, is likely to be associated with amyloid disease.

Pathological dislocation, as already pointed out, results from the pull of the stronger hamstrings and popliteus, and is due to destruction of the crucial ligaments and capsule, the joint assuming a position of flexion with external rotation of the tibia and dislocation of that bone backwards behind the femoral condyles. Inasmuch as articular cartilage is sure to be destroyed, fibrous or bony ankylosis is inevitable.

Treatment. 1. This is essentially prophylactic when the case is seen early enough, *i.e.*, in cases of suppurative osteitis prompt incision and drainage is to be practised (Chapter XVIII., p. 538), so as to save infection of the joint, while in all cases of wounds of the joint prompt excision, suture of the synovial membrane and drainage of the wound track, should be carried out as advocated (Chapter XV., p. 444), and the limb fixed on a Thomas's splint. In cases where doubt exists as to whether the joint is involved it may be justifiable to fix the limb on a Thomas's splint and watch, but it is safer to excise the wound, taking care not to open the synovial cavity if it be found that the wound has not involved this; at any rate remember, "*never probe*," because of the danger of carrying infection to the deeper part of the wound (Chapter IV., p. 42).

2. Once infection is established and effusion is present, *aspiration*, which must be carried out under general or local anæsthesia, and with all aseptic precautions, should be practised promptly; some of the fluid withdrawn is received into a sterile test-tube and examined for the causative organisms, and a vaccine prepared.

Aspiration should be carried out beside the patella; the fluid withdrawn in the early stages may be serous or opalescent, but usually is full of micro-organisms, while in the later stages it is usually frank pus, and a fairly large bore needle should be used, therefore, and attached to a large serum syringe, so that the joint may be emptied efficiently. If desired, when no more pus is obtained, a drachm of ether may be injected and allowed to diffuse in the joint; the knee must then be fixed in extension, best in a Thomas's knee splint, and maintained therein in a slightly flexed position. The effusion may recur, and then further aspirations may be performed, unless the local or general conditions indicate increase of infection and toxæmia, when more drastic treatment is indicated.

In such cases the joint cavity must be opened, swabbed out, and sewn up, a tube being inserted down to the wound in the synovial membrane, but not across or into the joint cavity, as this tends to the formation of bands of dense adhesions along its track. Adhesions, of course, always form, consequent on granulations and destruction of articular cartilage, but if these are of equal density throughout there is some hope of establishing some mobility on manipulation subsequently; in order to ensure this some authorities recommend that the joint be opened up by a transverse incision across the ligamentum patellæ, the patella reflected upwards, and the joint packed tightly with sterile paraffin gauze, which needs changing twice daily under gas anæsthesia.

If tubes are inserted it must be remembered that the ligamenta alaria tend to adhere to the peripheral synovial membrane and cause " pocketing," and, secondly, that though the joint is usually opened and best approached by incisions on either side of the patella, the joint must be drained at its most dependent point as the patient lies in bed, *i.e.*, by an incision down to the synovial membrane on the outer side of the limb between the biceps tendon behind and the posterior border of the iliotibial band anteriorly, care being taken not to cut the external popliteal (peroneal) nerve, which is lying posteriorly under cover of the biceps tendon. Unless this counter-incision is made, efficient drainage and amelioration of toxæmia and local inflammation cannot be hoped for, and will not occur, as the incisions lateral to the patella only drain the top of a large septic tank. It is not necessary to leave tubes down to the sutured synovial membrane in these lateral patellar incisions; merely leave the superficial tissues unsutured.

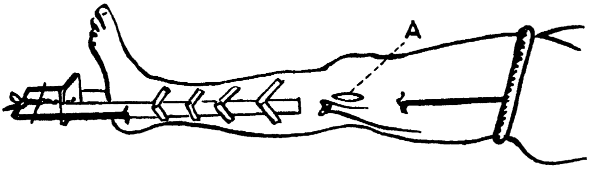


FIG. 337. Incision for draining the knee joint; the leg is fixed in a Thomas's splint by a strapping extension.

Whichever method be used, no good will result unless the joint is maintained fixed with extension in the Thomas's splint throughout (Chapter XIV., p. 429).

In the great majority of cases the patient's general and local condition will now improve steadily, though pus often escapes through the postero-lateral tube for several days; but occasionally, and especially in cases secondary to purulent osteitis, either blood-borne or secondary to compound fracture (Chapter XIX., p. 599), the general toxæmia increases, and then prompt amputation of the limb, through the thigh above the infected joint, must be carried out to save the patient's life. So frequently had this to be resorted to in gunshot wounds with compound fracture during the late war that many surgeons judged it better to amputate immediately in these cases of compound fracture with involvement of the knee joint rather than to risk the patient's life by conservative measures to try and save a limb the subsequent utility of which was doubtful. When the active inflammation has disappeared and wounds have healed, the knee should be fixed in plaster of Paris for at least six months if the joint is known to be disorganised; but in less severe cases a walking caliper may be substituted for the same period, and faradism and massage given, while gentle active and passive movements may be attempted cautiously, if necessary under anæsthesia, so as to endeavour gradually to restore mobility without causing recrudescence of symptoms.

The *prognosis* is always grave in septic infections. Ankylosis, with a stiff or at best slightly movable knee, is all that can be hoped for, while loss of limb, or even of life, must be contemplated seriously.

Diagnosis. An X-ray film is not usually helpful in the acute stages of the disease, as no bony change can be demonstrated, though when articular cartilage has been destroyed and muscle spasm holds the bone surfaces in contact, this can be observed and the absence of the space between the bone ends normally occupied by cartilage noted on the X-ray negative. It must be remembered that *separation of the lower femoral epiphysis* or *fracture of the condyles* is always accompanied by sudden and painful distension of the joint cavity with blood. The extreme general toxæmia and severe local signs, often with rapid onset, subsequent to a wound usually make a diagnosis of acute suppurative arthritis beyond doubt, but occasionally :—

1. *Pyæmic infection* may give rise to difficulty, the knee condition being regarded as primary unless careful examination is made for a primary focus or other pyæmic foci are found, especially in the lungs, spleen or other joints. The onset is usually not obvious till an effusion is noted ; marked pain and local reaction are usually absent, and, as already noted, a rigor frequently precedes the local signs. Difficulty also may be caused by :—

2. *Hæmophiliac Knee.* Effusion of blood into the knee joint of boys and youths occurs suddenly and after very slight trauma in those subjects affected with this disease, and also in scorbutic cases ; there is often considerable local heat and pain, which, unless careful interrogation elicits the history of "bleeding," may be mistaken, on a careless examination, for suppurative inflammation, and be so treated, with disastrous results (p. 618).

3. Rheumatic, scarlatinal, gonococcal, and similar inflammatory infections may cause errors in diagnosis, but aspiration will clear up the diagnosis by showing the nature and flora of the effusion.

4. *Acute prepatellar bursitis,* especially if the pus has burst from the bursa, may to the uninitiated, or on a cursory examination, simulate acute infection of the joint ; but all the swelling is superficial to the patella, the outline of which is obscured, though some effusion can be detected in the joint itself.

5. *Rheumatic infection* is common in this joint, especially in children ; there is sudden effusion, with pain and muscle rigidity, and frequently erythema or purpura in the skin, which may suggest septic infection. Other joints will be, or soon become, involved, and other signs of rheumatic fever, cardiac lesions and acrid sweats, will be observed.

The *treatment* consists in rest and the administration of aspirin.

Pyæmic Effusions. **Typhoid, Scarlatinal and Dysenteric and Influenzal Infections** are occasionally met with, but not nearly so often as in the hip.

Clinically an effusion appears in the joint during the course of the disease, which may or may not be painful, and which on aspiration is purulent or opalescent and contains the organisms of the disease.

Treatment consists in immobilisation of the limb in an extension splint and aspiration, combined with suitable general treatment.

Pneumococcal Arthritis is a pyæmic condition by no means uncommonly complicating pneumonia in children and adults, the joint effusion showing green, curdy pus and containing the pneumococcus. It also follows upon acute otitis media.

Treatment, as in all pyæmic effusions, consists in aspiration, repeated if necessary, the joint being maintained immobile on an extension splint. This treatment is usually sufficient, but occasionally incision may be necessary ; drainage should be avoided, as secondary pyogenic infection is liable to occur. There is usually more or less fibrous ankylosis, with limitation of movements at the joint.

Simple Pyogenic Pyæmic infection may occur in any septic condition, especially after bone disease, in which case the condition may become "chronic," effusion or abscesses appearing painlessly and with little local reaction at intervals for some years after cessation of the acute infection. In the more acute cases the local reaction is more marked, and the condition in the knee is typically one of acute suppurative arthritis.

Treatment, as pointed out, consisting in fixation in extension and aspiration repeated if necessary, usually cures the local condition, but some permanent damage to the joint frequently remains. Ether may be injected after aspiration, and occasionally more drastic methods, as indicated for primary suppurative infection, may be required. Of course the primary infective focus must receive suitable attention.

Gonococcal Arthritis is fairly common in this joint, and as is usual when a large joint is attacked, only one joint is affected and suppuration frequently occurs (Chapter XIX., p. 596). The infection is, of course, blood-borne and secondary to a primary mucous membrane infection, usually in the urethra, though active discharge from this may cease with the onset of the joint lesion, which nearly always occurs with dramatic suddenness. Infection is at first in the fasciæ and tendon sheaths around the joint, so that *clinically* there is marked perisynovial thickening, stiffness, and often œdema, with a small serous (sterile) sympathetic effusion; and if the condition is correctly diagnosed in this stage and the joint rested, then resolution often occurs without serious joint involvement. If, however, the patient uses the limb, suppuration occurs in and around the joint, which becomes greatly distended and acutely painful, with dusky œdema around, the skin appearing shiny and the pus being found to contain many gonococci.

Diagnosis in this stage rests between the true condition and acute rheumatism or pyogenic arthritis, but the real state of affairs usually can be elucidated by careful local examination, which shows much periarticular thickening, and signs of gonorrhœal infection are found elsewhere; demonstration of gonococci in the aspirated effusion is, of course, pathognomonic. As in all cases of gonorrhœal joints, improvement may take place up to a point, especially if suppuration does not occur; and the condition then becomes chronic, when the solid white periarticular swelling often leads to a diagnosis of *tuberculous arthritis* on a superficial examination; but the absence of marked muscle wasting and of bone changes in the X-ray picture usually will save error in such cases.

The *treatment* of the joint condition consists essentially of rest with extension, and as both false and true ankylosis usually occur, the joint should be fixed in nearly full extension (5–15 degrees flexion), as this is the most useful position. Fixation is best secured by plaster of Paris, but a Thomas's splint should be used when suppuration is present and plaster applied later. The joint must be kept at rest for at least six months, and all attempts to obtain movement by manipulation should be very cautious, as they are nearly always productive of a brisk recrudescence following the disruption of the dense peri- and intra-articular fibrous adhesions.

The gonorrhœa, of course, should be treated (Chapter VI., p. 87).

Hæmophiliac Effusion is commoner in the knee than any other joint, probably owing to its exposed position and liability to trauma. The condition is only met with in males, usually young, and is characterised by sudden, and often apparently causeless, effusions of blood into the joint. The condition is frequently recurrent during "bleeding" periods, and in time the synovial membrane becomes thickened and fibrous from organisation of clot, so that it is easily palpable between effusions; in museum specimens it can be seen to be orange yellow in colour from deposit of hæmatoidin and other blood pigments (Fig. 324).

Clinically there is a sudden effusion, sometimes after trauma, and the joint is distended and very tense, for only the pressure in the synovial cavity checks the hæmorrhage. There is considerable pain, the skin is hot, and the joint held semiflexed, but there is no marked muscle spasm. Inquiry will elicit a "bleeder's history," and the synovial membrane of the knee may be felt thickened.

Care must be taken not to mistake the condition for suppurative arthritis or acute rheumatism.

Treatment. Never aspirate, as hæmorrhage continues till death occurs. The limb should be elevated on pillows and a pressure bandage applied. Horse serum and calcium salts may be given by mouth or injected, and a blood transfusion may temporarily stop further bleeding.

Scorbutic hæmorrhage similar in character may be met with in subjects suffering from scurvy, and calls for similar treatment combined with antiscorbutic remedies. In infants the joint effusion consequent on *separation of the lower femoral epiphysis*, either from trauma, or more often from congenital syphilis, may be mistaken for scorbutic or hæmophiliac hæmarthrus, but the taking of an X-ray photograph will establish a correct diagnosis at once.

CHRONIC INFECTIONS OF THE KNEE JOINT

Tuberculosis of the Knee Joint. As in any joint, tuberculous infection is either primarily osseous or synovial, but in the knee the latter type of infection is relatively more common than in other joints, though, of course, not more frequent than the osseous variety. In both types the disease is chronic and insidious of onset, though the sudden bursting of an abscess through the epiphysis, with consequent involvement of the articular cartilage, often leads to an acute exacerbation, which may be noted as an "acute tuberculosis of the knee."

1. *The osseous type* usually commences in the diaphysis at the head of the tibia, but may start in the lower end of the femoral shaft, and very rarely disease may exist in both these regions contemporaneously. As already pointed out (Chapter XVIII., p. 548), the tuberculous focus more commonly spreads to the joint through the epiphyseal cartilage and epiphysis than along the diaphyseal side of the epiphyseal line. Articular cartilage is, therefore, early involved, and muscle wasting and spasm are marked and rapid, as in all tuberculous joint disease secondary to bony lesions. The cartilage is rapidly and irregularly destroyed, often flaking from the underlying carious bone, in which caseous foci or crumbling sequestra, wedge-shaped with their base to the cartilage (Chapter XVIII., p. 547), can be detected; the synovial membrane is gelatinous and œdematous, and granulates over the carious bone at the denuded articular facets; tubercles or caseous areas may be seen in it. In late cases surrounding structures are destroyed, and abscesses or sinuses may be present with marked periarticular thickening and infiltration, but the skin remains white and puffy, earning the condition the old name of "*white swelling of the knee*" (Figs. 335, 338).

Destruction of the intra-articular fibrous cartilages, with pathological dislocation of the joint into the typical position of "*triple displacement,*" *i.e.*, flexion and external rotation with backward and upward displacement of the tibia behind the femoral condyles, is succeeded by ankylosis in this position in untreated cases—fibrous ankylosis in pure tuberculous infection, and bony if secondary pyogenic infection has complicated it as a result of sinus formation (Fig. 336).

Similarly only a small amount of feathery subperiosteal new bone is laid down around the tibia and femur as an inflammatory reaction to the tuberculous infection, but if sepsis has supervened, then the typical massive coral-like osteoperiostitis is met with; this is seen in many of the older specimens of "tuberculous" knee which have been complicated by sinus formation.

2. *Synovial infection* is, as already stated, comparatively uncommon in relation to the bony type, though more frequently met with in the knee than elsewhere. The synovial membrane is often first affected in the suprapatellar pouch, where an irregular thickening can be detected, which has led to this variety of the disease being called "König's nodular tuberculosis." If left untreated a generalised infection of the membrane occurs, and this granulates and invades the edges of the articular cartilages; there is, of course, early and marked synovial effusion.

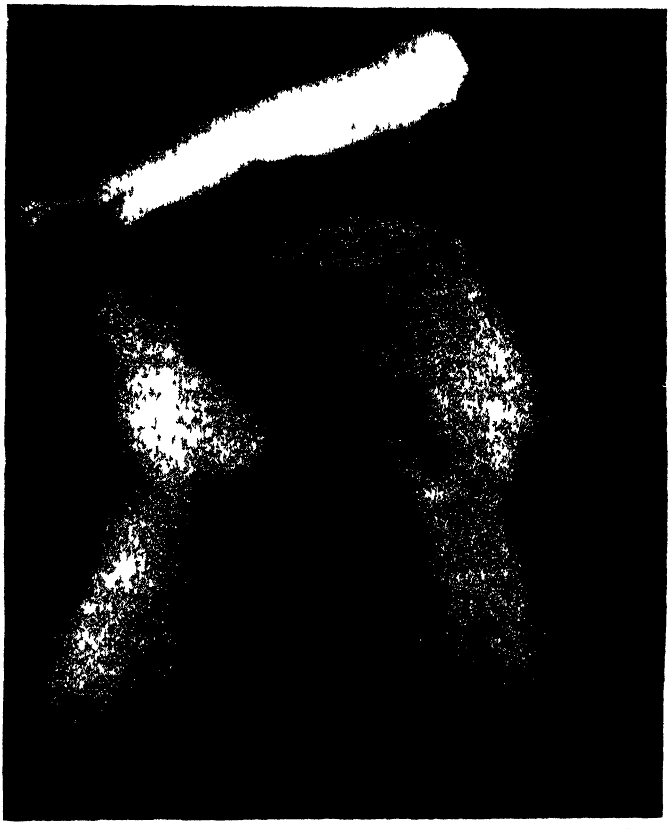


FIG. 338. Effusion in a knee joint due to synovial tuberculosis. Note bulging out of the suprapatellar region which masks the muscle wasting.

Clinically the onset is gradual, but presents certain differences in the osseous and synovial types, though in the later stages the physical signs are identical.

1. *The osseous type* should be detected, if possible, before the joint is involved (Chapter XVIII., p. 549), *i.e.*, when there is a bone abscess with a slight serous sympathetic effusion in the joint, some muscle wasting and loss

of tone, pain on exertion and tenderness on percussing the affected end of the bone. Gradual increase of all these symptoms culminates suddenly with the bursting of the abscess through the articular cartilage into the joint, an event signalised by sudden muscle spasm, marked limitation of movement, and the onset of "starting pains" and effusion, showing that articular cartilage is diseased. As already mentioned, this sudden exacerbation is sometimes erroneously described as "acute tuberculosis" of the joint.

2. The *synovial type* is ushered in by the appearance of a steadily increasing effusion, which usually reaches a considerable size, so that the lateral patellar sulci are obliterated, a patellar tap is present, and full extension painful. Apart from this the condition is practically painless. Muscles around the joint are flabby and wasted, but not markedly spastic, and as a consequence the affected knee appears much larger than its fellow, both actually and relatively. This stage may last many weeks, and continues till the articular cartilage becomes involved.

The stage common to both types is that at which the disease is unfortunately all too commonly first recognised, and, as will be realised by a study of the signs, it is the stage of disease of the articular cartilage, corresponding to the second stage of hip disease. There is marked muscle wasting, so that the femoral condyles are unduly prominent, a condition accentuated by the flexed position in which the generalised muscle spasm and stronger hamstrings hold the joint; in consequence the knee looks relatively larger than its healthy fellow, though measurement will show it actually smaller owing to muscle wasting. The skin is white, although hotter than that on the healthy side, and there is usually some effusion in the joint, with consequent fulness around the patella, though this can seldom be felt to tap. The synovial membrane is irregularly thickened and can be palpated easily beneath the wasted quadriceps. All movements are resisted and limited, and a history of "starting pains" always can be elicited.

In the last stages, corresponding to the third stage of hip disease, the intra-articular ligaments are destroyed by granulations, and the joint becomes disorganised, lateral mobility can be obtained, and the continued muscle spasm leads to pathological dislocation, the joint assuming its characteristic position of triple displacement (p. 640), in which it is ultimately fixed by true fibrous ankylosis.

Abscess formation (caries suppurativa) or sequestra (caries necrotica), or both, may occur, and if the condition progresses the abscess will burst and a sinus result, with all the added risks of pyogenic infection (p. 640); in such a case the ultimate ankylosis is bony in type.

Treatment consists essentially in complete rest combined with extension, the joint being fixed in about 10 degrees of flexion. The best method of treatment is by the application of a plaster of Paris splint under anæsthesia, the position of the joint being gently adjusted and the plaster, which extends from just above the malleoli to two-thirds of the way up the thigh, carefully moulded over the femoral and tibial condyles; it is well to incorporate a webbing brace in the upper end of the plaster, so that the weight can be borne by a sling over the shoulders. This splint must be worn at least six months after the cessation of all signs of active disease, and a patten carried on the boot of the sound leg, so that the patient can get about on crutches without bearing weight on the diseased limb. Thereafter a Thomas's knee or walking caliper splint may be substituted and worn for a further period of six months. In cases of synovial tuberculosis, or where a bone abscess exists, such an ambulatory splint may constitute the initial treatment, and often will ensure sufficient immobility to effect a cure. It, of course, must be worn at night also for the first six months, and has the additional advantage of permitting heliotherapy throughout. In cases where great spasm and flexion exist, rest in bed with a weight-and-pulley extension attached below the knee may be a useful preliminary to ensure correction of faulty position prior to fixation in a splint.

Aspiration and biopsy should be avoided as a general rule, owing to the danger of sinus formation following infection of the track of the needle.

Where sinuses exist two methods of treatment can be adopted :—

1. Fixation in a skeleton extension splint of the Thomas's type and heliotherapy ; this method is likely to succeed, provided secondary infection and extensive caries necrotica are not present.

2. Excision of the joint (p. 728), with removal of all diseased bone and synovial membrane and fixation in plaster. This method gives excellent results, but as it is likely to cause interference with the growing ends of the bones and consequent stunting, it should be avoided in young children ; it is particularly valuable in securing a stable fixed knee in agricultural labourers and is more economical of time than the conservative method ; moreover, the presence of secondary infection is of advantage as tending to promote firm bony ankylosis. Owing to the shortening of the limb, a raised boot is usually required.

Where abscesses are present these need repeated aspiration, or incision and curettage.

Disorganisation of the joint and fixed triple displacement are best dealt with by excision or, if amyloid disease be present, by amputation, which should be performed through the middle third of the femur.

The *prognosis* is best if the disease is diagnosed while confined to the bone, when a useful mobile joint may be hoped for, or in those cases where synovial disease is detected early, when a similar result is usually obtained. Once cartilage is ulcerated, fibrous ankylosis in a favourable position is the best that can be hoped for. As in any bone or joint disease, the presence of night sweats or lesions elsewhere are of grave significance.

Diagnosis. This is usually easy in the later stages, but in the early stages, when if a good result is to be obtained it is essential that the condition be correctly diagnosed, many difficulties may present themselves. The presence of early and marked muscle wasting, irregularly thickened synovial membrane, or an X-ray film showing caries of bone are suggestive of tuberculosis ; but other conditions, such as *osteogenic sarcoma*, or more rarely *endosteal sarcoma* with a slight joint effusion, may cause difficulty unless the X-ray film is carefully examined, while *chronic gonorrhœal arthritis* is very similar. Here an X-ray film shows no changes in the bone, there is marked periarticular thickening, and other joints may be involved.

Brodie's abscess (p. 541) may cause difficulty, and can, of course, be a precursor of tuberculous synovitis. *Gummatous synovitis*, or effusion associated with tertiary osteitis, may cause uncertainty, though here there is a tendency to find the corresponding joint on the other side affected, and there are usually other stigmata of the congenital or acquired disease, with a positive Wassermann reaction. In young children seen for the first time a *subacute rheumatic* infection may closely simulate the bursting of a tuberculous bone lesion through the cartilage, but X-ray films and the administration of aspirin or salicylates will establish the diagnosis.

Osteoarthritis in adults may simulate tuberculosis closely, especially if of the villous type, but here the pain improves with use, whereas in tuberculosis use aggravates the condition. *Chronic internal derangement* always leaves undue lateral mobility and muscle spasm is absent.

It must be remembered that occasionally transient œdema and effusion occur in *renal disease*, and if any doubt exists the urine should be examined for albumen and casts.

Lastly, it may be well to remind the reader that should no local cause be found for pain in the knee, he must examine the hip and sacroiliac joints, as pain may be referred from them.

Gout is not infrequently met with in the knee joint in elderly persons and sometimes may occur without the first tarsometatarsal joint being involved. The articular cartilage is wrinkled and infiltrated with a white deposit of sodium biurate and the synovial membrane thickened and shaggy.

Clinically the onset is sudden, often in the night, the joint acutely distended and very painful, the skin red and shiny, and all movements deeply resented.

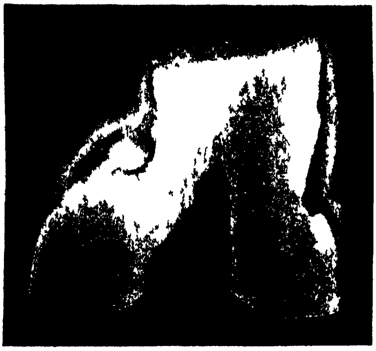


FIG. 339. Deposit in the articular cartilage of the lower end of the femur in a case of gout.

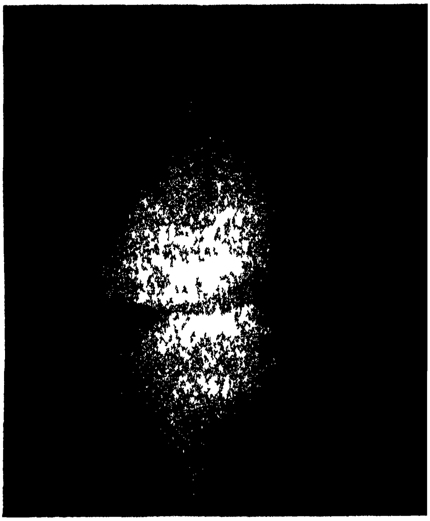


FIG 340. Osteoarthritis of the knee joint, with lipping.

There may be a history of previous attacks. Between attacks some effusion often remains and the synovial membrane can be felt thickened, while fine creaking accompanies movements.

Treatment consists in elevation and rest and the administration of vinum colchici (Chapter VI., p. 136).

The *diagnosis* is usually clear, but care must be taken that septic arthritis is not confused in the acute stage, and the villous form of osteoarthritis is likely to be diagnosed if the joint is seen between attacks and no history elicited.

Osteoarthritis is frequently met with in the knee joint of elderly persons and is often of the traumatic monarticular type; owing to the superficial position of the joint, lipping can be readily detected, and the condition is easily diagnosed when this sign is present, though it may be hard to elicit in the case of very obese patients, usually women.

1. *In the synovial type* great hypertrophy of the synovial fringes occurs, and these usually get nipped at intervals between the articular facets, causing sudden exacerbation of pain and effusion, which are, however, always present

in some degree. Movements are usually free and full, and in old cases laxity of the ligaments due to chronic distension may permit lateral mobility; fine crepitus is always present, and in old-standing cases a slight amount of lipping usually can be detected. Baker's cysts are often present, especially in the popliteal space.

The *diagnosis* is usually obvious, as X-ray films show absorption of cartilage with undue approximation of the bony articular surfaces, but occasionally tuberculosis, chronic gonorrhœal arthritis or chronic gout may give rise to difficulty, especially if no X-ray film is available. In the rare cases where atrophic Charcot's disease occurs in the knee, errors of diagnosis may occur if the central nervous system be not examined.

2. The *chondro-osteal* type is much more often seen and presents all the typical appearances of this variety of the disease (Chapter XIX., p. 610), the cartilage being eroded at the pressure points, and the softened underlying bone grooved anteroposteriorly and eburnated by the joint movements. Lipping is frequent at the edge of the joint surfaces, and ossification often occurs, such cartilaginous or bony "exostoses" being easily palpable under the skin, and often reaching considerable size, when they may become detached, forming "loose bodies" in the joint. Movements are usually limited, often mechanically by the osteophytes, and are accompanied by a coarse grating often audible to the patient. Other joints may or may not be affected. X-ray films will reveal the lipping if calcification or ossification has taken place.

The condition is usually obvious, but occasionally failure to examine the central nervous system may lead to *Charcot's disease* (hypertrophic) being called osteoarthritis, the lightning pains of tabes passing for joint pains.

In both varieties there are considerable wasting and flabbiness of the muscles around the joint, but neither so early of onset nor so marked as in tuberculosis of the knee.

Treatment consists of suitable measures for detection and elimination of septic foci (Chapter XIX., p. 612) combined with local treatment in the form of hot air baths, Scott's dressing, ionisation, etc., all of which may have a temporary ameliorating effect, but relapses are frequent. On the whole, better results are obtained in the synovial type. Change to a dry, warm climate and spa treatment are useful, and the wearing of a knee-cap or thermogene wool serves to keep the joint at an even temperature and often eases pain. In monarticular cases and in labourers, the question of excision, with a view to obtaining a stable ankylosed and painless joint, is one very well worth consideration.

Charcot's Disease is fairly common in persons, usually of the male sex, who suffer from tabes dorsalis, and is more often of the hypertrophic variety; the atrophic type, however, does occur occasionally, and is then usually sudden in onset, with complete disorganisation of the joint, which is flail and the limb consequently useless; the atrophic type is also seen in other nervous diseases, such as spina bifida, Friedreich's ataxia and syringomyelia.

In the hypertrophic variety the onset is usually gradual, the joint becoming progressively more deformed and unstable, but the patient often stumps cheerfully into the room with the characteristic high-stepping, dropped-foot, stamping gait of tabes, and will continue to use the joint until there is too much laxity and instability to enable the limb to support the body. The condition is painless, but it must be remembered that such patients often complain of pain, which careful questioning will always show to be of the stabbing, shooting type, *i.e.*, the characteristic "lightning pains of tabes."

Examination shows enormous deformity of the bone ends, with numerous exostoses, which may be separated and often reach the size of a cricket ball. Movements are possible in all directions and hyperextension is frequently present, as well as lateral mobility; no pain can be elicited, though coarse grating accompanies the movements of the joint. There is often effusion, which may be large in amount, and a characteristic hard, non-pitting thickening of the subcutaneous tissues is present around and below the joint, the skin over which looks unduly white, but is otherwise normal. Backward dislocation of the tibia is frequent. In pathological specimens the bony masses around the edges of the bones are very marked and usually chalky and friable, while the articular cartilage is absent and the bone worn away and grooved by the movements in an anteroposterior direction; the intra-articular ligaments are destroyed, and this permits the tibia to be displaced backward, but the absence of any muscle spasm prevents "triple displacement," and the painlessness of the condition allows of the dislocated knee being walked on, so that the femur is worn away behind and the tibial head in front, in a sloping manner (Figs. 321, 322).

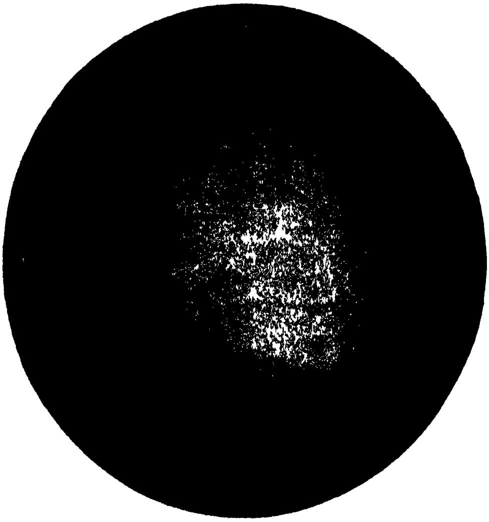


FIG. 341. Hypertrophic Charcot's knee joint.

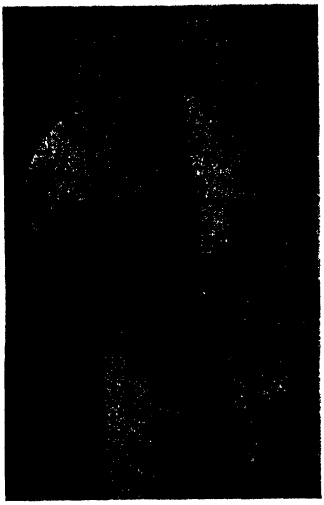


FIG. 342. Sarcoma of the synovial membrane of the subcrureal pouch.

In the atrophic type the ends of the bones have disappeared and lie in a distended synovial sac with thickened walls.

Treatment consists in stabilisation of the joint by some light support to permit of use of the leg; it should be realised that the ataxic patient cannot carry any heavy or complicated apparatus, and that the skin is liable to trophic ulceration, especially at pressure points. Should infection occur amputation through the thigh will be necessary, and this may be advisable in cases where the joint is so completely disorganised that the limb is useless, but it should be remembered that wounds in tabetic subjects do not always heal easily.

Diagnosis is always obvious if the central nervous system is examined for signs of tabes dorsalis, or other nerve lesions, but if this examination is omitted the condition in its early stages may be mistaken quite easily for some form of osteoarthritis. If infection has occurred a simple pyogenic arthritis may be diagnosed and the tabes escape notice.

Hysterical Knee is met with occasionally, and next to the elbow is the joint most often involved, the patients usually being of the female sex and sometimes quite children in age.

The knee is usually held either rigidly extended or flexed and the muscles tightly contracted; often an effusion is present, but this may have been induced (see p. 653); excruciating pain is complained of. Any attempt at movement is actively resisted and no wasting or loss of tone is generally present in the muscles; other stigmata of hysteria, such as sharply delimited anæsthesia and absent palate reflex, may be present. Should any doubt exist as to the diagnosis a general anæsthetic should be given, when muscle spasm passes and the joint will be found normal, which is not the case under N_2O anæsthesia if disease be present in the joint.

Treatment consists in general antihysterical measures as indicated (Chapter XIX., p. 619); movement under gas anæsthesia, with the joint held ostentatiously in a new position and moved as the patient " comes round," is often a valuable corrective.

Malingerers and hysterical subjects may cause effusion into the knee joint by flicking the supra- and lateral patellar regions with a wet handkerchief, spring or hair brush, till a traumatic synovitis is induced. This, of course, passes off in a few days unless opportunity occurs to renew the effusion, and there is always œdematous thickening and sometimes ecchymosis in the skin and subcutaneous tissue of the regions so treated. This means is employed by soldiers, sailors, or workmen desirous of being invalided from their service with a pension for " synovitis," or in order to avoid conscript service.

Intermittent Hydrops Articuli was a name given by the older surgeons to any condition in which recurrent effusion appeared in the knee joint (or other joints) and was due to a variety of causes, the commoner of which are:—

1. Brodie's abscess or other chronic osteitis near the joint.
2. Osteoarthritis.
3. Syphilitic synovitis, secondary or tertiary.
4. Renal disease.
5. Internal derangement.
6. Malingering.

The effusion usually appears after exertion. It is doubtful if a true idiopathic recurrent hydrops exists, and if so it is very rare.

Neoplasms of the Synovial Membrane are very rare .—

1. Subsynovial lipoma is the commonest.
2. Sarcoma may be met with and induce a chronic effusion, which in this case may be hæmorrhagic; the synovial membrane is thickened, and the condition, apart from microscopy, is usually diagnosed as tuberculosis.

Treatment consists in local excision of a lipoma or fibroma and amputation for sarcoma.

Neoplasms of bone in this region have been fully discussed in Chapters VIII. and XVIII.

THE ANKLE JOINT

This joint is the articulation between the upper facet of the astragalus with the tibiofibular mortice, consisting of the tibia above and on the inner side, and the fibula on the outer; the joint has considerable bony strength, being buttressed on either side by the malleoli. There is a complete, rather lax capsule reinforced, laterally by the cordlike triradiate external lateral ligament, which is attached in front and behind to the astragalus and between to the os calcis, and medially by the broad bandlike internal lateral ligament, which extends from the tip of the internal malleolus of the tibia to the os calcis and splits to enclose the tendons of the tibialis posticus and plantar flexors.

The wedge-shape of the astragalar facet, narrower behind than in front, renders posterior dislocation impossible without fracture of one or other malleolus, and at the same time permits only flexion and extension. Thus the ankle is a hinge joint, though slight lateral and medial rotation are possible in plantar flexion when the narrower posterior astragalar facet is engaged in the tibiofibular mortice.

The synovial cavity is simple and lined by synovial membrane attached to the inner aspect of the capsule and around the lips of the articular facets; closely applied to the joint capsule externally, both anteriorly and on either side, are tendons and tendon sheaths, while posteriorly is a pad of fat deep to the tendo Achillis.

Effusion into the joint can be diagnosed readily, as there is a fulness anteriorly across below the tibia, and posteriorly a swelling can be detected on either side of the tendo Achillis; both swellings are tenser and more prominent in dorsiflexion of the joint.

A sympathetic effusion may be present in the surrounding tendon sheaths, which appear as elongated, fluctuating swellings around the front and sides of the joint, and care must be taken to discriminate between such tenosynovitis (Chapter XIII., p. 390) and effusion in the ankle joint.

Disease of the ankle joint may be either acute or chronic, and is due to a variety of causes as in the hip and knee joints.

Clinically there is effusion into the joint, the skin over which is hot and may be red and tender in acute inflammation. The calf muscles and the extensor brevis digitorum, which normally causes the prominence on the dorsum of the foot, are flabby and wasted to a varying degree as compared with the other side, while effusion may be present in the tendon sheaths around the joint. It is not easy to detect synovial thickening. Dorsi- and plantar-flexion may be considerably limited as compared with the sound side, a very necessary examination, as the range of normal ankle movements varies much in different individuals. There may be œdema around the joint, which is very marked in gonorrhœal cases.

Acute Arthritis may be due to (1) *pyogenic infection* from the lower end of the tibia or fibula in acute osteitis or rarely from the astragalus, or it may be (2) *rheumatic* in origin, when purpuric rashes are common, other joints usually affected, and general signs of acute rheumatism present. (3) *Gonorrhœal infection* is fairly common, and then there is always much periarticular œdema and involvement of tendon sheaths—more rarely *pneumococcal, hæmophiliac,* etc., effusions are met with.

Treatment consists in rest, with the joint fixed in full dorsiflexion, so as to permit of walking; an attempt to secure extension may be made by strapping applied to the heel, which is not usually successful, or by a pin through the os calcis. If pus is present the joint must be drained by an incision to the outer side of the tendo Achillis and a tube passed down to the incised synovial membrane; ankylosis often results.

Chronic Arthritis is usually (1) *tuberculous,* most often secondary to infection of the lower end of the tibia, and presents all the signs described in Chapter XVIII.; owing to the superficial situation sinus formation is not uncommon. An X-ray film will show caries of the diseased bone.

Treatment consists in immobilisation in a plaster of Paris splint in full dorsiflexion; but if starting pains persist or sinuses develop, then erasion or excision of the joint, through a transverse anterior incision (p. 728), should be carried out promptly, and the joint fixed in dorsiflexion so as to secure firm ankylosis and a stable joint which will permit walking.

(2) *Osteoarthritis* is frequently of the bony type, and exostoses can be both felt and seen on X-ray examination; there is often considerable pain and disability, with limitation of movement and effusion.

The best treatment is probably prompt excision, which secures a painless joint ankylosed in dorsiflexion.

Charcot's Disease of the hypertrophic type may be met with and, like osteoarthritis, is often associated with similar disease in the tarsus and much swelling. The patient will walk about on a shapeless disorganised joint.

The best treatment, especially if the tarsus be involved, consists in amputation through the new seat of election (p. 721).

Intermittent chronic effusion into the joint is met with in Brodie's abscess of the lower end of the tibia or more rarely of the fibula, and a chronic effusion also occurs in osteoclastoma and sarcoma in these situations; an X-ray film will establish at once the nature of the lesion which is causing the effusion and the thickening of the lower ends of the bones.

Serum synovitis and effusion in exanthemata occur fairly often in the ankle joint and can be controlled by aspirin. *Gout* is also met with.

THE TARSAL JOINTS

These joints form a common cavity around the tarsal bones and bases of the metatarsals, and communicate freely, except in the case of the posterior astragalocalcaneal and first metatarsotarsal joints; hence in the majority of cases infection in one place means rapid involvement of the whole of this intricate synovial sac. It follows, therefore, that tarsal disease is rapid of spread and extensive, with in consequence a very grave prognosis as regards saving the foot. Inversion and eversion take place at the midtarsal joint and the articulations are strengthened below by the close application of the plantar ligaments and tendinous expansions which maintain the pedal arches.

Disease in the joints is clinically manifested by pain and œdematous swelling of the whole of the centre of the foot, this is especially marked on the dorsum. Inversion and eversion are both limited or absent, but unless the ankle joint is also involved dorsi- and plantar-flexion are painless and normal; in old-standing cases softening of the plantar ligaments and loss of tone and wasting of the short plantar muscles often lead to a pes planus.

Acute Arthritis is rare, but may occur not infrequently as the result of infection through a perforating ulcer (Chapter VII., p. 148) in tabes, and then, if infecting a tarsus involved in Charcot's disease, it leads inevitably to the loss of the foot. Owing to the complicated nature of the joint cavity it is useless to attempt drainage, and amputation, best by Syme's method (Chapter XXII.), should be carried out promptly.

Chronic Arthritis may be due to tuberculosis, osteoarthritis or Charcot's disease, while in India madura foot (Chapter VI., p. 135), from streptothrix infection, is by no means uncommon, the whole foot being flat, swollen and distorted and appearing typically shortened and broad due to destruction and absorption of tarsal bones. Sinus formation and secondary infection are not uncommon.

Treatment. In tuberculosis and osteoarthritis fixation in plaster of Paris, with the foot in dorsiflexion, may be tried, but if this fails to arrest the disease and relieve pain or if sinuses form, Syme's amputation should be performed;

this should be carried out without hesitation in Charcot's disease, especially if a perforating ulcer or much bone absorption and disorganisation be present.

The Metatarsophalangeal and Interphalangeal Joints are a series of hinge joints with strong lateral and plantar ligaments, and beyond the fact that they are frequently the seat of rheumatoid and serum synovitis merit no especial mention, except to notice that the first metatarsophalangeal joint is often the seat of gout (Chapter VI., p. 135) and osteoarthritis. This may be of the osteochondral type and associated with hallus valgus and bunion (Chapter XXI.), or of the synovial variety in young persons, when hallux flexus and rigidus complicate flat foot (Chapter XXI.).

THE STERNOCLAVICULAR ARTICULATION

This hinge joint is situated between the rectangular facet on the inner end of the clavicle and the facet on the supero-external angle of the manubrium sterni, which is overridden above and behind by the larger clavicular process; this is in close contact below with the inner end of the first rib, to which it is strongly attached by the rhomboid ligament and subclavius muscle. The joint is enclosed in a strong fibrous capsule, and the synovial cavity is imperfectly divided by a meniscus of fibrocartilage.

Signs of Inflammation. In the normal individual the sulcus between the manubrium sterni and the projecting clavicle is easily palpable; this is obliterated if effusion be present, and may even be replaced by a fluctuating swelling; at the same time movements of the shoulder girdle provoke plain and there is a sense of fulness experienced in the region.

Acute Infection is nearly always *gonococcal,* this joint being frequently and characteristically involved in gonorrhœal rheumatism. There is considerable œdema around the joint.

More rarely it may be affected secondarily to acute pyogenic osteitis of the clavicle or to pneumonia.

Chronic Infection is practically only met with in *osteoarthritis* or as a result of *tuberculosis,* and is often associated with infection of a like nature at the pulmonary apex, the joint infection occurring through the subjacent pleura; there is, therefore, considerable thickening of the tissues behind the joint and a matted mass of glands can often be left in the supraclavicular region in addition, while occasionally the lower part of the sternomastoid or subhyoid muscles may be found infiltrated and thickened. Signs of pulmonary disease can be detected with the stethoscope. Abscess and sinus formation are often present, with typical undermined and callous edges at the mouth of the latter.

More rarely gummatous or chronic gonococcal infection may be present in the joint.

Treatment consists in fixation by strips of strapping and supporting the arm, while abscesses are curetted freely and sinuses may be curetted advantageously and then treated with X-rays or ultra-violet rays.

If the pulmonary condition be not too advanced, excision of the joint may be practised, subsequent fixation being secured by a plaster of Paris spica around the neck and shoulder.

In gummatous or gonococcal cases rest secured by wearing the arm in a sling and general treatment directed against the cause will effect a cure.

THE ACROMIOCLAVICULAR JOINT

This is a sliding joint between the front and inner part of the acromion of the scapula and the anterior extremity of the outer end of the clavicle; it is surrounded by a strong capsule and rests inferiorly on the strong coraco-acromial ligament which forms the superior socket for the humeral head.

This joint is occasionally subluxated, and very rarely the site of infection in *gonorrhœal rheumatism* or *tuberculosis*, when a swelling can be detected around the joint and some pain is present, especially on abduction of the arm; *osteo-arthritis* is fairly frequent in elderly people and is troublesome and intractable.

Treatment consists in applying strapping over the joint and supporting the arm in a sling. Excision of the joint with ankylosis may be necessary.

THE SHOULDER JOINT

The articulation between the rounded humeral head and the shallow glenoid fossa of the scapula, depending as it does on muscles and ligaments for its stability, is capable of very free movement in all directions, but is very liable to traumatic displacement (Chapter XVI., p. 455); it is a ball-and-socket joint. The projection of the overhanging outer ends of the clavicle and acromion process, together with the strong triangular coraco-acromial ligament which lies below them, deepen and strengthen the socket above the upper end of the humerus, while the coracoid process, short head of the biceps and coracobrachialis support it on the inner side, the deltoid serving the same function externally and in front; strength is also given to the joint by the closely apposed tendons of the subscapularis (anteriorly) and supra- (superiorly) and infraspinatus and teres minor (posteriorly) as they pass to their insertions on the humeral tuberosities. Only on the lower or inferior aspect, therefore, is the humeral head unsupported, save by the capsule and the axillary fat and connective tissues, across which the vessel and cords of the brachial plexus pass into the arm, and it is here in consequence that the head escapes primarily in dislocations of the joint (Chapter XVI., p. 455).

In the normal joint the rounded prominence of the deltoid, supported beneath by the greater tuberosity, which can be felt to rotate with the arm, is a characteristic feature of the shoulder, above which can be seen and felt the hard, bony acromion process, most easily palpable postero-externally at the metacromion, and terminating antero-internally by articulating with the outer end of the clavicle, which is also subcutaneous. The anterior axillary fold presents the smooth, rounded prominence of the pectoralis major, while the posterior, which normally reaches lower and is formed by the teres major and latissimus dorsi, limits the depression of the axilla behind, in the apex of which the humeral head can just be palpated in a thin subject, as well as the lower lip of the glenoid fossa. The ribs are easily felt running across the inner wall in a direction from behind downwards and forwards. Above the pectoralis major and in the sulcus just beneath the clavicle (behind the braces), the end of the coracoid process of the scapula is palpable.

The joint is enclosed in a strong capsule, which is thinner below, and which anteriorly presents two or three thickened bands, the glenohumeral ligaments, between which there is a gap through which the synovial membrane projects to form the *subscapularis bursa;* this passes out to lie behind the subscapularis tendon and beneath the coraco-acromial ligament above the joint. The long head of the biceps brachii, arising from the upper end of the glenoid fossa, passes across the synovial cavity lying above the humeral head, and is enclosed in a double sleeve of synovial membrane, the inner lining of which is prolonged round the tendon after it emerges from the joint caspule, and lies around it in the bicipital groove as the *bicipital bursa.* Both these bursæ communicate with the synovial cavity of the shoulder joint, and are distended in any inflammatory condition of the joint; the *subdeltoid bursa,* however, does not communicate, lying as it does to the outer side of the humeral shaft and great tuberosity and beneath the lower part of the deltoid muscle.

The epiphyseal line of the humerus lies wholly within the joint capsule, the centres for the head and tuberosities fusing, it will be recalled, to form a hollow cap which fits over the convex end of the shaft. Small secondary centres occupy the glenoid fossa deep to the articular facet, which is deepened by the presence of the glenoid ligament around its periphery, this structure lying within the joint capsule and being covered with synovial membrane.

Detection of inflammatory effusion in the joint is by no means easy, as it lies deeply beneath the acromion and deltoid muscles, and is obscured anteriorly by the pectoralis major and posteriorly by the scapular muscles and latissimus dorsi, while below the axillary contents much impede examination. When effusion is present in some amount an undue fulness can be detected in the apex of the axilla, and internal rotation is painful and limited, owing to involvement of the subscapularis bursa. The biceps bursa can be detected sometimes as an elongated, fluctuant swelling passing down beneath the attachment of the greater pectoral, and becoming more tense when flexion of the shoulder and elbow are attempted ; these movements, as also supination of the forearm, are often painful and limited.

Signs of disease of the shoulder joint are much the same as elsewhere: (1) *Muscle wasting* and *loss of tone* are most obvious in the deltoid, which presents a flattened appearance and is flabby to the touch, but the pectoral and scapular muscles also can be seen to be smaller than those of the sound side. It must be remembered that " flattening " occurs in dislocatio humeri (Chapter XVI., p. 456), but whereas Hamilton's ruler test may be positive in both conditions, the other tests for dislocation are never positive, nor is there any hollow beneath the acromion, nor can the head of the humerus be detected in any abnormal position.

(2) *Muscle spasm* occurs as a sign of disease of the articular cartilage; the shoulder is adducted and internally rotated by the pectoralis major, latissimus dorsi, and subscapularis, which are stronger than the deltoid and abductors, and is usually slightly flexed by the biceps, so that the arm is held in to the side and front of the chest wall.

(3) *Limitation of all movements* occurs as a result of the spasm. In this connection it must be borne in mind that very free movement occurs at the pectoral girdle, so that, unless the scapula be fixed, ankylosis of the shoulder may be masked or even escape notice, so freely can lack of movement at the shoulder joint be compensated for; normally abduction to a right angle occurs at the shoulder joint, but any elevation above that is entirely due to movement of the pectoral girdle.

(4) *Effusion*, if present, can be detected sometimes by fulness in the axillary apex on palpation, and more rarely by fulness in the bicipital groove. Remember that rounded fulness and fluctuation under the deltoid, which looks unduly prominent, mean inflammation of the subdeltoid bursa (Chapter XIII., p. 401), and that this never communicates with the shoulder joint.

Pain is present of an aching type in synovial disease, and of a " starting " type when cartilage is affected.

Acute Inflammation of the shoulder joint is of rare occurrence and may be (1) a *true synovitis*, in which case it is usually due to acute rheumatism, and other signs of this disease will be present.

(2) *Pyogenic :* (*a*) Sometimes pyæmic after septic foci elsewhere in the body ; infections of this nature are particularly common, especially in the left shoulder, in malignant endocarditis, while the condition may be met with in gonorrhœa, pneumonia, influenza and scarlet fever ; (*b*) secondary to acute osteitis in the upper end of the humerus, the pus pointing along the epiphyseal line into the joint ; (*c*) rarely as a result of suppuration in the axilla.

Clinically there are all the signs of infection of the joint, attempts at movement are painful, and the upper limb is held tightly adducted to the side and slightly flexed and internally rotated. Swelling and œdema around the upper end of the humerus always suggest in a child septic osteitis, and in an adult gonorrhœal fasciitis, as a primary source of infection. Rigors and sweats are often present in pyogenic cases, and the typical acrid perspiration in rheumatism.

Treatment in rheumatic cases consists in rest in bed, with the arm supported on a pillow, and administration of salicylates.

If suppuration is suspected the joint should be aspirated, the needle being inserted behind just beneath the metacromion process, and pushed forward and inward through the deltoid for about an inch, when it can be felt to enter the joint; the operation causes some pain, and may with advantage be carried out under gas anæsthesia. Frequently the withdrawal of the pus, combined with fixation of the joint under extension in the abducted position, *i.e.*, at right angles to the trunk on an abduction frame, is sufficient to effect a cure; but if the temperature rises again, and in all cases of septic osteitis, the synovial cavity must be drained by an incision passing down to the joint through the posterior fibres of the deltoid, and the joint opened between the teres minor and infraspinatus muscles, a tube being left down to the joint in this position. Some surgeons prefer to open the joint anteriorly internal to the biceps long head, and make a counter-opening posteriorly on to a pair of forceps pushed across the joint.

In any case ankylosis of the fibrous type nearly always results, but causes very little disability provided the arm is fixed at right angles, owing to the free compensation in movements of the pectoral girdle as a whole. For this reason no attempt need be made to break down adhesions, unless either pain be present or abduction is very limited as a result of fixation of the joint in a faulty adducted position.

Diagnosis, as already pointed out, lies between *acute rheumatism* and *pyogenic infection* of the joint due to spread of pus from the bone (or the axilla in rare cases), and pyæmic invasion, of which gonorrhœa is the commonest cause; influenza, pneumonia, etc., may all be ætiological factors, especially if malignant endocarditis be present. As already stated, periarticular thickening is suggestive of primary bone trouble or gonorrhœal fasciitis. There are, however, certain conditions which may be mistaken for acute arthritis, and the commonest among these are:—

1. *Suppuration in the Subdeltoid Bursa* (Chapter XIII., p. 401). Here gentle manipulation and rotatory movements will show the joint normal, while there is undue deltoid prominence, the arm being most comfortable if supported away from the trunk in a position of passive abduction.
2. *Dislocation of the Humerus* (Chapter XVI., p. 455), especially if seen a few days after injury, when generalised swelling masks the position of the misplaced head and obscures the signs of dislocation. X-ray films will establish the diagnosis at once.
3. *Fractures* around the upper end of the humerus or neck of the scapula, especially if associated with dislocation (Chapter XVI., p. 452). Here, again, X-ray films will show the true nature of the lesion.
4. Occasionally *axillary cellulitis* or a *subpectoral abscess* on a superficial examination may give rise to errors in diagnosis, but careful local investigation will show the joint normal, and the detection of a primary focus on the upper limb or chest wall will at once allay anxiety as to the question of joint infection.

Chronic Infections are, like acute ones, not commonly met with in the shoulder joint, and when present are likely to escape detection unless careful clinical and X-ray examination are combined, as the free movement possible at the pectoral girdle often masks any limitation of movement.

The common infections are *tuberculosis* and *osteoarthritis*, both of which are of the osseous type and frequent in old people; indeed, the region of this joint is "par excellence" the seat of "senile" tuberculosis (Chapter XVIII., p. 547), which is often a true "caries sicca." *Syphilitic infections* and *Charcot's joint*, usually of the atrophic variety, also occur, the latter both in tabes dorsalis and syringomyelia (Fig. 320).

Clinically chronic infections of the shoulder joint fall into two distinct types: (1) *The primary osseous variety* (**caries sicca**), seen in both tuberculosis and osteoarthritis. Here the patient is often elderly, though the tuberculous form may occur in children and young adults, and the onset usually is insidious, with a history of gradually increasing pain and stiffness. Examination reveals marked muscle wasting, with deltoid flattening, a generalised spasm and loss of tone, the arm being adducted and internally rotated, and often slightly flexed, and all movements much limited or absent; though this may have escaped the notice of the patient, and may escape that of the surgeon unless the scapula is fixed during examination, as pectoral girdle movement compensates for it so largely. There is often spasm of the trapezius, the shoulder girdle being raised on the affected side. An X-ray film will establish a diagnosis at once between tuberculosis with rarefaction of bone (usually limited to the upper end of the humerus, and seldom seen in the glenoid), osteoarthritis with lipping, seen in both humerus and scapula, and absorption and flattening of the humeral head and glenoid fossa. Apart from X-ray films, however, there are two points which usually establish the diagnosis: (*a*) The pain in tubercle gets worse with use of the joint; that in osteoarthritis is worse in the morning after the night's rest, and improves on use: (*b*) The wasting is usually more rapid and much more marked in tuberculosis. Both these points, of course, apply to all joints, but are the only clinical difference to be observed in the shoulder in the great majority of cases.

Hypertrophic Charcot's disease is very rare in the shoulder, and approximates to a severe osteoarthritis in type.

(2) *The primary synovial variety* may be met with in the uncommon synovial forms of tuberculosis usually seen in children, and in osteoarthritis and *Charcot's disease* in adults.

Clinically the onset is often sudden, the effusion appearing in a few hours or days, and in the case of Charcot's disease being accompanied by severe pain of a "lightning" type and generalised œdema of the limb, which disappears in a few days, leaving a flail joint and a useless limb. A large effusion is present, and bursæ, such as the subdeltoid, which do not communicate with the joint, are often tensely distended, and are characteristic of this form of osteoarthritis as well as Charcot's disease. Examination should be made for signs of tabes and for the sensory changes characteristic of syringomyelia; should none of these be positive, then the effusion is probably due to tuberculosis in a child and osteoarthritis in an adult, though occasionally chronic pyæmia may be the cause of purulent effusion, with little signs of local reaction.

Treatment. Little can be done to better the flail-like, useless joint resultant on Charcot's disease, some form of leather shoulder cap giving the best support. Operative interference should never be undertaken, as ankylosis seldom results, and even healing of the soft tissues is unsatisfactory. Tuberculosis and osteoarthritis are best treated by aspiration and fixation of the limb on an abduction frame for a period of six to nine months, when firm fibrous ankylosis will probably occur. Occasionally excision (p. 729) and fixation in abduction is an operation productive of excellent results in both diseases.

Hysterical Contractures of the Shoulder are occasionally met with, the joint being held in any position; they call for no special comment.

THE ELBOW JOINT

This is the hinge articulation between the rounded transverse ridge of the lower end of the humerus and the hollowed facet in the anterior aspect of the upper end of the ulna and the cupped superior facet of the radius. The joint cavity is in direct continuity with the superior radio-ulnar joint, a trochoid (lateral pivot) articulation between the rounded sides of the radial head and the facet on the lateral aspect of the head of the ulna and band-like orbicular ligament. The olecranon process of the ulna forms a prominent projection posteriorly, being partly subcutaneous, with the olecranon bursa intervening between the bone and skin, while on either side of the joint the humeral epicondyles can be easily palpated, the internal (medial) being more obvious. Below the epicondyles, and between these and the olecranon, is situated under normal conditions a sulcus on either side, which is obvious both in flexion and extension, as is also the hollow in front of the elbow joint, in the depths of which the coronoid process and biceps tendon can be palpated.

The synovial cavity extends above the humeral epiphysis in front and behind, but laterally dips inferiorly to the epicondyles; it is attached to the margins of the coronoid and olecranon processes of the ulna, and reflected over the orbicular ligament to the neck of the radius; between the radius and ulna it dips down as a pocket into the superior radi-oulnar joint.

The joint is enclosed in a fibrous capsule, weak in front and behind, but strengthened on either side by a well-marked lateral ligament consisting of a number of band-like fasciculi. The flexors and extensors of the forearms arise in close connecttion on either side, the brachialis anticus is inserted anteriorly, and the triceps and anconeus posteriorly.

Effusion into the joint can be detected by observing obliteration, or even fulness, in place of the sulci on either side of the olecranon, and a sense of resistance in the anterior hollow. The patient holds the joint flexed to just beyond a right angle, and complains of a sense of tightness; pronation and supination of the forearm are limited in extent and painful, owing to involvement of the superior radio-ulnar joint, and the forearm is held in the prone or semiprone position.

Signs of infection in the joint are usually obvious, as the joint is comparatively superficial.

1. *Heat* is therefore obvious as compared with the opposite elbow, and œdematous swelling and redness may be present in acute infections.

2. *Wasting or loss of tone* of the muscles is noticeable, the origins of the forearm muscles being particularly affected, while the biceps, triceps and brachialis anticus are also, though not so markedly, flabby and wasted. This makes the whole elbow region appear unduly prominent, and, as at the knee, bone enlargement may be suspected on a cursory examination.

3. *Muscle spasm* as a result of disease of articular cartilage causes the joint to be held flexed to a right angle and the forearm to be pronated, while as a result of irritation of the heads of the flexors the fingers may be contracted on the palm; this is more marked in cases, usually gonorrhœal, where considerable periarticular fasciitis is present.

4. *Effusion* can be detected readily in the joint, and abscesses often may be present around it, or sinuses have formed in old-standing cases; these usually lie behind it, as the joint is partly subcutaneous in this region. Hence in all old-standing disease of the elbow sinuses are common, and secondary infections of a pyogenic nature are frequently met with, a fact of importance

in that the excessive spongy, coral-like osteoperiostitis of sepsis may often mask completely the original cause of the disease, especially if this has been tuberculosis, with its feeble regenerative osteoperiostitis (Chapter XVIII., p. 548). From this it also follows that ankylosis of the elbow is frequently bony in type.

5. *Movements* of course will be limited, complete extension being early lost.

6. *Pain* of a dull aching character is usually present; it is of the typical "starting" type when articular cartilage is diseased. It will be remembered that the ulnar nerve, passing down between the olecranon and posterior aspect of the medial humeral condyle, lies on the posterior joint capsule, and may be irritated, with resultant referred ulnar pain, or even invaded, when ulnar palsy results.

Acute Infection may be (1) *primarily synovial,* in which case (*a*) *acute rheumatism* is nearly always the cause, though rarely *gonorrhœa* and *gout* may affect the joint, which may also show serous effusion in cases of serum synovitis. (*b*) Occasionally a penetrating wound, usually on one or other side of the olecranon, may give rise to infection and pyarthrus, when the whole joint is swollen, hot and painful, and aspiration, carried out beside the olecranon on the lateral aspect, shows the effusion to be opalescent or frankly purulent; more rarely pyæmic infection may occur. (*c*) Blood is present in traumatic effusions, which are not uncommon in children, and often may be a complication of fractures of the lower end of the humerus (Chapter XVI., p. 466). Frank hæmarthrus is met with in hæmophilia, and the elbow is, next to the knee, the joint most often affected in boys suffering from this disease.

(2) *Primarily osteal,* with secondary joint infection from suppurative osteitis, usually of the lower end of the humerus, or occasionally following infection of a compound fracture in the neighbourhood, usually of the olecranon.

Rarely infection may reach the joint from periarticular suppuration, as from infected olecranon bursitis.

Pyarthrus, secondary to gonorrhœal fibrofasciitis, is by no means uncommon.

Clinically there are signs of an acute infection, with heat, pain, tenderness and swelling around the joint, more marked in pyogenic cases, while effusion is present, and all attempts at movement are painful and strongly resented; muscle spasm is marked and the joint held supported in flexion.

If any doubt exists as to the nature of the effusion, aspiration should be carried out promptly, unless the patient is a hæmophiliac. An X-ray examination will reveal the presence of bone disease or injury, and should be carried out in all cases.

Treatment in rheumatic and gouty cases is medicinal, and in traumatic cases consists in rest combined with massage and gently-modulated active movements, unless a fracture is present involving the joint (Chapter XVI., p. 465), the elbow being maintained between whiles in full flexion and the forearm supinated. In pyogenic effusion repeated aspiration along the outer side of the olecranon may be persevered with, as drainage is both difficult and unsatisfactory; the joint throughout is fixed in an extension splint of the Patterson type, with the elbow fully flexed and the forearm supinated, as ankylosis is liable to occur, especially in gonorrhœal cases.

Drainage, if necessary, must be carried out by an incision along the outer side of the olecranon process, which, if necessary, may be divided to permit free exit to the pus.

So soon as the acute stage has subsided, and in gonococcal infection especially, the joint can be fixed with advantage in flexion and supination in plaster of Paris, in which position it is maintained for several months till firm ankylosis has resulted. Attempts at movements are frequently accompanied by recrudescence of the disease, and if a movable joint is desired it is probably better to encourage ankylosis and perform excision (Chapter XXII., p. 730) several months later, when the disease is quiescent.

Rarely amputation through the arm may be required in pyogenic infection, more especially in cases of purulent osteitis or infected wounds.

In penetrating wounds immediate excision of the wound, with lavage and fixation of the joint, should be practised if the case is seen before infection is established; otherwise, *i.e.*, after twenty-four hours, fixation with extension and careful watching should be resorted to, and the joint aspirated or opened if pyarthrus is suspected (Chapter XIX., p. 593).

Differential diagnosis between the various acute infections is usually easy if careful attention be given to local and general examination of the case. Thus in *rheumatism* other signs of the disease will be present, in *gonorrhœal* infection there is much periarticular thickening and a primary focus, with sudden onset and improvement up to a point, while in *pyarthrus* the local signs of inflammation are marked, and bone tenderness and thickening are often present; or else signs of the primary focus can be detected, such as pneumonia, influenza, etc., and other pyæmic foci will be present.

There is one inflammatory lesion which may be mistaken for joint infection, namely, *suppuration of the olecranon bursa*, when there is usually considerable surrounding cellulitis; this may follow direct infection through a wound or be secondary to a septic focus on the hand or forearm. The inflammation is most intense over the posterior aspect of the joint, though subcutaneous œdema may extend forward around the elbow, so that the movements may be painful and limited. The axillary lymph nodes are usually enlarged and tender. Fluctuation is present over the olecranon, and no effusion can be detected in the joint. The condition rapidly subsides on incision of the bursa (Chapter XIII., p. 401).

Gout is most likely to be mistaken for this condition, as the olecranon bursa is often involved and acutely tender, and redness and œdema are present—but the onset is very sudden; no enlargement of the axillary glands exists. Gout in the elbow is uncommon and seldom present without manifestations in the smaller joints, notably the first tarsometatarsal (Chapter VI., p. 135). Injuries around the joint, especially fracture of the lower end of the humerus and "pulled elbow," may cause errors in diagnosis unless X-ray examination is used (Chapter XVI.).

Chronic Infections. These are primarily osseous in the vast majority of cases, *tuberculosis* and *osteoarthritis* being the most common ætiological factors, though *gummatous infection* and *Charcot's disease* also occur; *chronic gonorrhœal infection* and relapsing hæmophiliac hæmorrhages are occasionally met with as causes of chronic synovial and perisynovial thickening, with recurrent attacks of pain and effusion.

The signs of chronic disease vary somewhat with the cause, but the onset is gradual with increasing stiffness, limitation of movement and pain, which is aching at first while the disease is osseous, and becoming "starting" so soon as the articular cartilage is involved. Muscle wasting and loss of tone are marked, being especially noticeable and early of onset in tuberculosis; all the muscles are affected, the wasting of the origins of the forearm flexors and pronators from the medial side being particularly obvious. In consequence the bones appear unduly prominent and the affected elbow looks to be enlarged. As soon as cartilage is invaded, generalised spasm of the muscles around the joint occurs, and the elbow is held in a position of right angle flexion, with the forearm pronated and a tendency to carry the wrist and fingers flexed. Joint movements are all limited in both the elbow and superior radio-ulnar joints, so that there is much disability complained of. The synovial membrane can often be felt to be thickened and effusion can be detected by the bulging beside the olecranon; bursæ may be enlarged. New bone formation is usually slight in amount, but easily detected owing to the muscle wasting and superficial position of the bones. Abscess and sinus formation may be met with in advanced cases. An X-ray film should be taken as a routine and will show any bone lesions.

The *treatment* will vary somewhat according to the cause, especially in regard to general treatment. The joint may be treated either (1) by immobilisation in plaster of Paris applied under anæsthesia to secure extension, and left on for several months so as to procure firm ankylosis. The position in which the joint should be fixed will depend on the work of the patient; thus a manual labourer probably will find nearly full extension with supination the best position, while a clerk or sedentary worker needs fixation of the elbow in three parts flexion and midway between supination and pronation. (2) The alternative method of treatment is excision of the joint (Chapter XXII., p. 730), with the object of removing all disease and securing either a fixed or movable joint. A fixed joint is to be aimed at in manual workers, and fixation in plaster of Paris will secure this without the necessity of operation, while a mobile joint is only too often " flail " and weak, though it may be of advantage in professional workers.

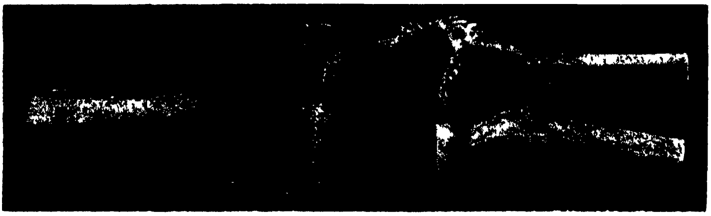


FIG. 343. The bones of the elbow joint in an old-standing case of tuberculosis, showing caries and loss of cartilage. Note the spongy new bone from septic osteoperiostitis, showing that secondary infection has occurred down sinuses.

If abscesses exist, fixation combined with aspiration probably will effect a cure, though occasionally incision, curettage and suture may have to be resorted to. Sinuses often heal under rest, but if necessary curettage and sequestrectomy, with subsequent fixation to secure healing, may be resorted to.

The *diagnosis* between the various types of chronic infection usually may be arrived at by a study of the clinical signs and X-ray films.

Tuberculosis more often occurs in young persons, but may be senile in type, and is nearly always primarily a bone infection in the humerus, the abscess pointing into and involving the joint. There is, therefore, in most cases a long history of aching pain, with gradually increasing disability and marked muscle flabbiness and wasting before the joint is actually involved; later muscle spasm, starting pains, limited movement and effusion, with perhaps synovial thickening, become marked. In the later stages the apparently enlarged, flexed elbow, with rather œdematous, white, shiny skin, is characteristic and well merits its old name of " white swelling." An X-ray picture in the early stages usually shows a carious focus in the lower end of the humerus, with perhaps a little fluffy new bone around, and in the later stages destruction of the articular cartilage, with the joint surfaces approximated and the articular ends of the bones carious and feathery in outline.

Abscess formation is by no means rare, fluctuation being easily detected, most often posterolaterally; the abscess, if neglected, usually bursts and forms a sinus along which secondary pyogenic infection reaches the diseased bone and joint, in which case excessive spongy new bone formation occurs and necrosis with sequestrum formation is not uncommon. Ankylosis frequently results and is always fibrous in type, unless secondary pyogenic infection has occurred, when it may be osseous; the joint is flexed and the forearm pronated in neglected cases.

Osteoarthritis is frequent in elderly people, especially agricultural workers, and is about equally often of the chondro-osteal and villous synovial types. In either case the disease starts in the joint surfaces, so that signs of joint disease—effusion, starting pain, and muscle spasm—are of much earlier onset than in tuberculosis, in spite of which muscle wasting is less marked, and the pain, unlike that in tuberculosis, is worse first thing in the morning and improves with use of the joint. In the villous type effusion is marked, the synovial membrane thickened, and X-ray films show little or no change in the bones, though in late cases there may be absorption of articular cartilage with approximation of joint surfaces, the bone being generally rarefied.

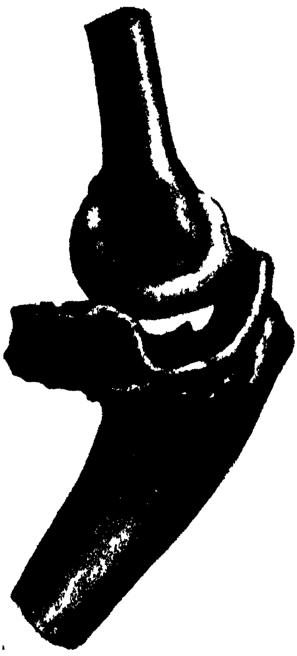


FIG. 344. Osteoarthritis of the elbow joint.

Effusion is common in the olecranon bursa and Morant Baker's cysts are often present, especially in the antecubital fossa.

The chondro-osteal type shows the typical changes met with in all joints so affected (Chapter XIX., p. 610), with creaking, limitation of movement and lipping, which is easily palpable and may be very marked. X-ray pictures will show the osteophytes and grooving of the bones, as well as the absorption of the articular cartilage; but it must be remembered that in early cases, where lipping is easily detected clinically, no shadows will show in the X-ray film if no calcification of the cartilaginous processes has yet taken place.

In both varieties *loose bodies*, synovial or osteochondral, may not uncommonly occur, though not so frequently as in the knee joint; these may become nipped and give rise to recurrent attacks of pain and exacerbation of effusion, in which case they should be removed through an incision on the lateral (outer) aspect of the joint. If difficult to extract, syringing the joint cavity with saline will float them out.

Gummatous synovitis is uncommon and the irregular thickening of the synovial membrane, which is easily palpable, usually breaks down and gives rise to extensive gummatous ulceration around the joint unless the disease is promptly treated. Pain is negligible and effusion marked, muscle wasting slight, and the opposite elbow and other joints often affected.

Charcot's disease may be either hypertrophic or atrophic in type, and is usually fairly sudden in onset, being thus diagnosed from osteoarthritis, as well as by the signs of tabes dorsalis or syringomyelia.

Chronic gonorrhœal infection causes great pain, firm ankylosis and chronic effusion with marked periarticular thickening; relapses are common, but the condition seldom clears right up unless the primary focus is treated.

THE WRIST, INFERIOR RADIO-ULNAR, INTERCARPAL AND CARPO-METACARPAL JOINTS

These form, with the exception of the first carpometacarpal (trapezio-metacarpal) joint, one vast and very intricate joint cavity lined by a common synovial membrane, so that any infection of one joint will lead to rapid involvement of all, with widespread infection and serious consequences.

The *wrist joint* lies about two fingers' breadth above the palm of the hand, lying approximately under the uppermost of the three creases across the wrist, and is a hinge joint between the proximal row of the carpus and the lower end of the radius and triangular ligament of fibrocartilage; this latter structure lies across the lower end of the ulna, being attached at its apex to the base of the ulnar styloid and to the inner edge of the articular facet of the radius, except at the spot where a gap in this attachment permits a process of synovial membrane (processus sacciformis) to pass up into the communicating inferior radio-ulnar joint. The wrist joint has a complete fibrous capsule thickened at each side to form cordlike lateral ligaments. The radial and ulnar styloids are readily detected on palpation, the radial lying at a somewhat lower level on the lateral aspect and having just below it the hollow (anatomical snuff-box), in the bottom of which the tubercle of the scaphoid (os naviculare) can be palpated, and the pulse of the radial artery detected on deep pressure.

The *inferior radio-ulnar joint* lies above the wrist (with which it communicates) between the facet on the inner aspect of the radius, and the convex articular surface around the lower end of the ulna and the upper aspect of the triangular fibrocartilage and is a lateral pivot (trochoid) joint. Its synovial membrane is formed by an expansion from the wrist as indicated above.

The intercarpal and carpometacarpal joints (except the first carpometacarpal, which is a separate entity permitting double hinge movements of the thumb) form a complicated series of sliding joints, much cut up by strong intercarpal and carpometacarpal ligaments, around which the synovial membrane is continuous from one to another.

The *synovial membrane* is continuous throughout the whole series of joints enumerated above, and forms a vast complicated maze, to the outer aspect of the capsule of which the flexor and extensor tendons and their sheaths are closely approximated. The palmar ligaments are dense and maintain the palmar arches in conjunction with the short muscles of the hand, but are here worthy of note only in so far as their density prevents effusions and œdema in the joints showing in the palm, though these may be detected readily by the swelling on the dorsum of the hand (*cf.* Infections of Flexor Sheaths, Chapter XIII., p. 391).

Acute Infections may be *rheumatic*, but are nearly always *gonorrhœal*, in which case there is often suppuration both in the carpus and surrounding tendon sheaths; infection from pyogenic organisms other than the gonococcus is rare, but may follow penetrating wounds, whitlows, suppuration in tendon sheaths, and occasionally osteitis suppurativa in the lower end of radius or ulna or carpal bones, when an X-ray examination will reveal bone lesions.

Clinically there is acute pain in the wrist and hand, which are held flexed, and considerable swelling on the dorsum; fluctuation may be detected, as also a sense of fulness on the front of the wrist. There is often some effusion in the tendon sheaths, with consequent limitation of finger movements, and in gonorrhœal cases this perisynovial inflammation is very marked. The region is hot and may be red if suppuration is present, the abscess, if neglected, bursting into and infecting the tendon sheaths. Ankylosis, with a stiff hand, is the best result to be expected in gonorrhœal cases.

Treatment consists in fixing the joint in hyperextension on a cock-up splint or plaster of Paris and aspirating if much effusion exists. Suppuration calls for prompt lateral incisions and drainage, but severe infection of the whole synovial sac, with disorganisation and infection of tendon sheaths, usually occurs rapidly, and amputation through the lower third of the forearm is occasionally called for

Diagnosis between the joint infections is usually easy, *gonorrhœa* being by far the commonest cause and showing great periarticular thickening and a primary focus in the urethra. *Rheumatism* is not common, and is associated with other signs of the disease, while *serum synovitis*, though frequent about ten days after injection, is usually associated with urticaria and infection of other small joints. Suppurative arthritis other than that due to gonorrhœa is uncommon.

It is essential that traumatic lesions, such as sprains, fractured and displaced carpal bones and Colles's fracture, be eliminated by the history and stereoscopic X-ray examination. Effusions and suppuration in the flexor sheaths call for prompt treatment, while careful examination will show whether the underlying joints are infected, especially the fact that pronation and supination, which are painful or impossible in joint infections, can be painlessly carried out with gentleness when the tendon sheaths alone are infected.

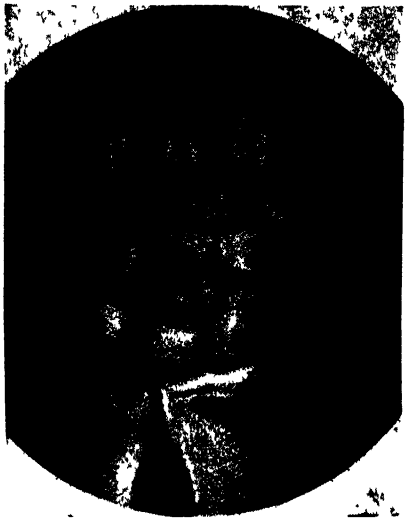


FIG. 345. Tuberculous caries of the carpometacarpal region. Note the loss of clearness of the joint line.

Chronic Infections are not uncommon, both *tuberculosis* and *osteoarthritis* being met with frequently, while *Charcot's disease* and *syphilitic infections* also occur, the last-named being usually in the form of a gummatous synovitis; the other conditions in the majority of cases are primarily osseous, but spread to and throughout the whole synovial cavity and carpal bones is rapid and serious, the hand being rendered stiff and useless.

Clinically all the general signs of chronic infection, pain, muscle wasting and loss of tone, rigidity and limitation of movement can be detected readily; effusion is not so easy to make out, as it is limited in amount, and reaches the surface only beneath the radial and ulnar styloids between the tendons, where it causes a slight visible fulness and a sense of resistance on palpation, which can be detected also in front of the joint. The hand and wrist are rigid and flexed, and the fingers often adducted and flexed owing to involvement of the short muscles and tendon sheaths. Bursæ and sheaths around the joint may be distended with fluid, especially in the villous form of osteoarthritis, when Baker's cysts are frequent. Abscesses and sinuses may be present in old-standing tuberculous and gonorrhœal cases and are a sign that amputation is necessary, for no other treatment will be successful in removing the many sequestra and leaving a mobile, useful hand.

Treatment consists in fixing the hand in plaster of Paris for three or six months in the hope of obtaining ankylosis in a favourable position; but often the disease spreads and the whole carpus becomes a painful, disorganised mass, with abscess or sinus formation, when amputation through the lower third of the forearm must be carried out, as excision (p. 730) gives very unsatisfactory results.

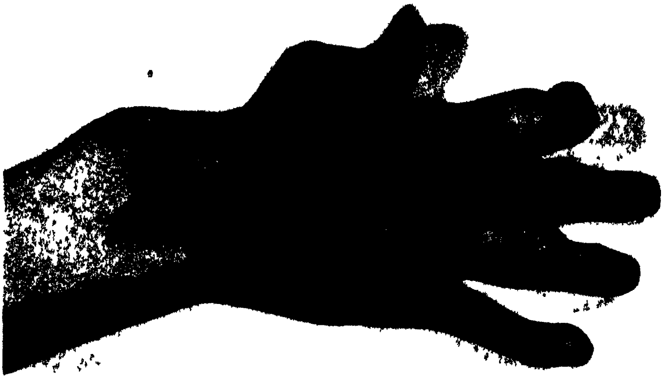


FIG. 346. Hand of a patient suffering from chronic gout, showing the deformity due to the presence of numerous tophi.

Diagnosis between the various forms of disease is by no means easy, even with the aid of X-ray films.

Tuberculosis is perhaps the most common and occurs more often in adults than in children, usually starting in the carpal bones, which are often actually enlarged (Chapter XVIII., p. 552, Spina Ventosa). Wasting in the forearm is marked, and starting pain early and severe. Infection of the flexor sheaths is frequent in late cases, a compound palmar ganglion, in which perhaps melon seed bodies can be detected, often resulting (see p. 396).

Sinus and abscess formation are common in late cases, the carpus being reduced to a carious disorganised mass of spongy granulating bone, when amputation is urgently indicated.

X-ray films show in the early stages caries of one or more carpal bones, often with generalised enlargement from osteoperiostitis (spina ventosa), or if the lesion has started in the radius or ulna, a localised carious patch with a little fluffy new bone. Later a carious disorganised carpus and wrist joint are revealed and resemble the changes in Charcot's disease, for which they may be mistaken.

Osteoarthritis is common in adults, and if of the chondro-osteal type closely resembles tuberculosis in its physical signs, save that wasting is less, pain better on use, which may provoke crepitus, and definite lipping can be detected both on palpation and on X-ray examination. The villous type usually occurs in younger people ana may have a more sudden onset, there being great pain and effusion, while the surrounding tendon sheaths are distended and Baker's cysts present in old-standing cases. Large pouches of synovial membrane are often seen protruding on all sides of the joint. X-ray films show the bones unduly approximated owing to absorption of cartilage (Fig. 315).

Charcot's disease occurs in tabes dorsalis or syringomyelia and may be hypertrophic or atrophic, X-ray films showing complete disorganisation of the carpus, often with marked atrophy and absorption of the bones and no osteoperiostitis (a condition also met with in leprosy). Lightning pains may be present, and the hand rapidly becomes useless, with a peculiar bulky, semi-œdematous infiltration of the soft tissues.

Chronic gonorrhœa leads to a flexed, useless hand, with much periarticular fibrosis in neglected cases. Where the joint has been hyperextended ankylosis will be in this position. Chronic pain and effusion remain if the primary focus be not cured.

Chronic pulmonary osteoarthropathy (Chapter XVIII., p. 566), with bony enlargement, may be mistaken for tuberculosis or osteoarthritis, but an X-ray film shows the joint lines normal and the new bone is laid down in regular layers; the clubbing of the fingers and signs of chronic pulmonary disease will clear up the diagnosis at once.

Compound palmar ganglion (Chapter XIII., p. 396) sometimes may give rise to a suspicion of wrist joint infection, which is often present, but if any doubt exists it can be removed or confirmed by X-ray examination.

THE METACARPOPHALANGEAL AND INTERPHALANGEAL JOINTS

These form a series of hinge joints, with a fibrous capsule strong at the sides and anteriorly, but weak posteriorly, where it is, however, reinforced by the close approximation of the extensor tendons.

The joints are acutely painful and distended in gonorrhœal rheumatism, serum synovitis, and rarely post-dysenteric synovitis—occasionally they become infected from a whitlow, especially if subperiosteal.

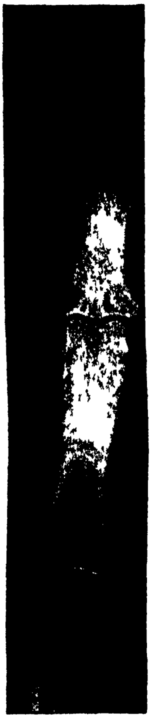


FIG. 347. Gout. Tophi and clear areas in the second phalanx.

Chronic infection is always osteoarthritic, usually of a mixed type, there being absorption of articular cartilage and bone which is more marked on the ulnar side, so that ulnar deviation of the fingers results; while lipping may be extensive, producing the thickened gnarled fingers, so characteristically seen in agricultural workers, or more localised, causing nodules around the joints (Heberden's nodes).

Gout occasionally occurs in these joints, when the overlying purplish swelling is liable to be mistaken for cellulitis (Chapter VI., p. 135) and tophi may be present; these are not fixed to the bone like Heberden's nodes.

THE TEMPOROMANDIBULAR JOINT

This is the hinge-like articulation between the condyle of the mandible and the glenoid facet in the temporal bone lying just beneath the middle ear. The joint has a fibrous capsule and a meniscus of fibrocartilage which projects across the cavity from its anterior wall; here this is attached both to the capsule and the tendon of the external pterygoid, so that it is pulled forward with the jaw in protrusion and does not curl up and cause derangement so long as this muscle is attached and intact. The pterygoids, temporal and masseter muscles, all supplied by the motor root of the fifth cranial nerve, are closely approximated to the joint, which derives both its movements, hinge and gliding, and considerable stability from these muscles.

The joint can be felt just in front of the tragus of the ear deep to the zygoma, and can be best detected by opening and shutting the mouth with the finger placed in this situation. The plate of bone between the middle ear and the bony external auditory meatus above and the joint below is thin, so that infection may pass from one region to another with comparative ease, and moreover, as the parotid gland is intimately associated with the joint, abscess in either is liable to infect the other.

Disease of the joint causes pain and swelling in front of the ear and tenderness in this region, while the proximity of the auriculotemporal nerve may lead to referred earache or temporal headache. Owing to the discomfort of opening the mouth, the patient is morose and silent, and usually only takes liquid food.

Acute infection is nearly always suppurative and secondary to gonorrhœa, but may be due to extension of infection from the parotid or middle ear. The abscess usually breaks externally and ankylosis is frequent. Serum synovitis very seldom affects the joint. Pyæmic arthritis is common.

Chronic infection is rare, but osteoarthritis does occur in the joint.

Diagnosis is usually easy owing to the pain, preauricular swelling and trismus, but certain other conditions may cause errors in diagnosis, as they cause trismus and swelling in the region.

1. *Parotid Abscess.* Here the pain is continuous, intense and of a throbbing character, while the swelling is very generalised to the face and neck.

2. *Infective parotitis* (mumps), most often occurs in children—the swelling goes below the jaw and salivation is free ; it is usually bilateral.

3. *Impacted wisdom tooth* may in young adults give rise to trismus and swelling of the face ; the gum is swollen and tender and X-ray films show the offending tooth jammed in the angle of the jaw.

4. *Otitis media or meatal furunculosis*, with earache and enlargement of the preauricular gland and pain on opening the mouth, may lead to misdiagnosis unless the ear be examined. As already mentioned, the conditions may coexist with pus in the joint.

5. *Tetanus* causes trismus, with rigidity on both sides and no swelling.

Treatment consists in rest and fluid diet, unless suppuration occurs, when an incision must be made beneath the zygoma and the joint drained ; in this case ankylosis is likely to follow, unless the mouth is gagged open regularly two or three times a day for some months. If ankylosis occurs it is usually bony and excision must be practised ; this is generally carried out through an ┌-shaped incision below the zygoma and in front of the ear ; the results are fairly satisfactory if a fascial graft is implanted (Vol. II., Chapter IV.).

Internal derangements due to nipping of the meniscus, from injury or weakness of the pterygoid (external), or more rarely in osteoarthritis, may give rise to " clicking jaw " and need dealing with through a similar incision, but the results are unsatisfactory (see also Vol. II., Chapter IV.).

CHAPTER XXI

DEFORMITIES OF THE LIMBS

It is in the limbs especially that many deformities will be encountered, and it is to deal with and endeavour to correct these deformities that the orthopædic surgeon originally came into existence. The expression "deformity" is a wide one, including conditions which are due to very many different causes, and in most instances the correct treatment will depend upon the cause. The two main groups are the congenital and the acquired types.

(*a*) **Congenital Deformities.** Congenital deformities are those which are present at birth, having commenced while the child was still in utero. They may be inherited, or the result of some abnormality in the health of or trauma to the pregnant mother; they may be consequent on errors of development in the form of supernumerary parts or deficient and absent parts. Other congenital cases are thought to be due to the fœtus taking up abnormal positions in utero, possibly as the result of deficient liquor amnii or an abnormally small uterus, while it is possible that amniotic bands lying within the uterine cavity will help to produce these deformities and in some instances may be responsible for the absence of whole or parts of limbs by constricting them and actually severing them. There are certain general diseases of the fœtus which affect its skeletal growth before it is born, such as achondroplasia and fragilitas ossium. Certain other so-called congenital deformities are really due to an injury to the child at birth as a result of a severe labour.

Generalised congenital deformities may take the form of monsters (which are not discussed in this work), giants (see p. 566), or dwarfs. The causes of dwarfism may be achondroplasia (see p. 563), cretinism (see Vol. II., Chapter X.), rickets, osteogenesis imperfecta, osteomalacia (see p. 566), infantilism, progeria (early old age), and such causes as spinal caries and syphilis.

(*b*) **Acquired Deformities.** These are by far the larger class and may be the result of many different conditions. Thus deformities of this kind will be due to injuries, inflammatory conditions following injury, diseases of the osseous system, such as rickets, osteomalacia, syphilis, etc., various diseases of the joints, the result of unsuitable and badly fitting clothing, prolonged standing in a faulty position, over-exercise of certain parts of the body, etc. Inasmuch as the growth of bone is very largely dependent upon the strains and stresses to which it is subjected, any of the above conditions are particularly liable to lead to irregular bony growth. A very large number of deformities are the result of injuries and diseases of the nervous system, which may cause deformity in a variety of ways, by producing, it may be, spasm of certain muscle groups, paralysis of other muscle groups, trophic changes in tendons, ligaments and soft tissues, trophic changes in the bones and joints, etc.

It must not be forgotten that certain of these conditions, though not strictly congenital, arise at and during birth; thus injuries will occur during birth, and these may damage important nerves or important muscles and tendons, while the result of injuries to the head during birth which have given rise to hæmorrhage over the cortical motor areas, is a series of spastic deformities known as Little's disease.

Whichever of the causative conditions above described is at work, it will be found that the deformity itself is the direct result of the lesions affecting one or more anatomical structures, while in most instances a combination of structures will be affected ultimately, although one may be primarily at fault.

(*a*) *The Bones.* Many deformities are due primarily to faulty conditions of the bones, which may be the result of non-union or malunion or irregularity or deficiency of bony growth from many different causes.

(*b*) *The Ligaments.* These are often the cause of deformities commencing in the joints. Thus the ligaments may be torn, stretched, and relaxed, ossified or shortened, and contracted as the result of various traumatic, toxic and inflammatory processes.

(*c*) *Diseases of the joints* leading to alteration of their bony surfaces are frequent causes of deformity; in many cases these are associated with ankylosis of the joint.

(*d*) *The action of muscles* is of great importance, this usually taking the form of an unbalanced action of opposing groups ; thus one muscle group may be paralysed, leaving the opposing group free to produce deformity, or a muscle group may be in permanent or temporary spasm and thereby overcome or tire out its opposing muscles.

(*e*) *Diseases of the nervous system*, which, as above described, cause paralysis, spasm and trophic changes.

(*f*) *Contractions of the soft tissues*, *i.e.*, the skin, fasciæ and muscles, as the result of injuries, burns, etc., will lead sometimes to gross deformities.

It must be remembered that nearly all deformities with the exception of congenital ones are the results, often late results, of gross and detectable disease. They all therefore, the congenital cases again excepted, should be looked upon as preventable conditions, and there is no doubt that they are much more easy to prevent than to cure.

It must be remembered that persistent malposition of any part, limb or joint always leads to anatomical changes, the tendency of which is to retain that part in the malposition, these anatomical changes taking the form of contraction and shortening of certain structures, alteration of growth and shape of other structures and stretching and lengthening of certain tissues, and the tendency of these anatomical changes is to be permanent.

There are certain general principles in the production of deformities which are of the greatest importance in their treatment, more especially with regard to those deformities which are the result of lesions of the muscles and nerves. Thus if a muscle reacts to the Faradic current, though it may appear to be paralysed, it will probably recover, while if it exhibits the "reaction of degeneration" (see p. 330), it is not likely to recover, although there are exceptions to this rule. Mere overstretching of muscles from faulty position by itself will cause them to become permanently elongated and useless, while if the muscles were paralysed before being overstretched, the stretching produces even more serious permanent harm. Any stretching, therefore, of a paralysed muscle is to be avoided carefully by placing and keeping the limb in the proper posture. It must be remembered that this stretching of muscle groups often, in the leg at any rate, will be the result of erroneous deflection of body weight, which in itself may be caused by muscle palsies.

In the treatment of deformities many important methods are employed. One important principle is that the deformity should be overcorrected temporarily at any rate. Limbs should be fixed in such a position that paralysed muscles are completely relaxed in the hope that they may recover their power, while prolonged over-correction of the deformity will give the soft tissues, and even the bones, a chance of regaining their shape. The correction of such a deformity may be gradual or rapid, according to the method employed, and it may be achieved by such procedures as manipulation, gradual extension, splintage and supporting irons and the employment of plaster of Paris. Exercises and various physicotherapeutic measures for restoring the function of the soft tissues, combined with massage and muscle re-education, will be of the greatest assistance, while in many cases operations of the most varied nature will be required. Thus contracted bands of fascia and skin may have to be divided; tendons and muscles may need lengthening; stretched structures may need shortening; bones may need dividing and replacing. Excising areas of skin on one or other side of the limb sometimes will help to keep a joint in its proper position, while tendon transplantations to replace paralysed muscles, or to reinforce weak muscles, or to hold bones and joints in position where ligaments have failed, are often of the greatest use. In other cases arthrodesis to strengthen joints by producing firm ankylosis and bony osteotomy to correct deformities will be required.

Operations upon the nervous system are not infrequently performed for these deformities. Thus nerve suture, nerve anastomosis, Stöffel's operation directed upon the individual fibres of certain peripheral nerves, and resection of certain posterior nerve roots for spastic conditions are often beneficial.

In connection with deformities commencing in children and young people there are two diseases, one of which, at any rate, is common and far-reaching in the surgical conditions which follow in its track, which, although they may be regarded strictly as medical conditions, merit a short description here.

Infantile Paralysis (Acute Anterior Poliomyelitis). This is thought to be due to the virus of an anaerobic organism somewhat resembling a coccus, difficult to culture and so far unclassified. The disease possibly may be conveyed by the bites of flies, while monkeys can be infected with the virus; it is most common in children under four, but it may be seen at any age and occurs especially during the summer and autumn, while at times small epidemics occur, and it appears to be infective, so that several members of one family suffer simultaneously from it. The motor cells of the anterior cornua of the spinal cord suffer chiefly and are destroyed, so that a muscular paralysis occurs of the lower motor neurone type with degeneration of the nerves and marked wasting of the muscles (see Vol. II., Chapter III.). The lesions in the cord consist of areas of small round-celled infiltration around the anterior horn cells, with hæmorrhages; the nutrition of the cells is affected, and though they may recover, they are most commonly destroyed and degenerate.

The disease comes on suddenly as a febrile illness, with malaise, vomiting, convulsions, pain in the back and limbs, and headache. After three or four days paralysis appears in one or more muscle groups affecting the whole or part of one or more limbs. This paralysis reaches a maximum in a few hours, then remains stationary for three or four weeks or longer, when it begins to diminish and pass off to some degree both in its severity and extent; improvement may continue slowly for weeks and months, but the paralysis practically never recovers completely. The paralysed muscles are helpless, flaccid and waste rapidly, showing the reaction of degeneration and absence of deep reflexes. Those muscle groups which remain paralysed continue in this state, become very badly nourished and much wasted, while the limb is cold and bluish in colour. Growth in the limb does not occur properly; the skin is poorly nourished and liable to develop pressure sores, and after a short time, if not properly treated, severe deformities will occur, due to the stretching of paralysed muscles and the over-action of their antagonists. The muscle groups especially affected by this disease are those of the leg, the quadriceps extensor and adductors, the deltoid, the extensors of the forearm and supinator longus, and occasionally the abdominal and dorsal musculature.

A certain number of cases die in a few days from the severity of the paralysis, which may affect the vital centres, while in other instances the acute stage is so slight as to be hardly noticeable. In most cases a remarkable amount of recovery of power occurs.

Treatment. The treatment in the early stages consists in improving the general health, while serum may be given, but is of doubtful value. Some of the damaged nerve cells are undoubtedly capable of recovery, and every care, therefore, must be taken to prevent deformities, and not to allow the paralysed muscles to become stretched, by means of suitable splintage, while their nutrition is preserved as far as possible by massage and electrical treatment. In the later stages any of the forms of treatment already described for deformities and weak muscle groups may be necessary; thus mechanical support in the form of irons, splints, special boots, etc., tenotomies, tendon lengthening or grafting, fixation of joints, nerve anastomosis, etc., may all be useful. In severe cases where the whole limb is hopelessly paralysed, shrunken, cold, and liable to cutaneous sepsis, so that it is an inconvenience to the patient, amputation may be necessary. It must be remembered, however, that the skin of such a limb does not form good stumps, and that often healing will be defective.

Cerebral Palsies in Children (Little's Disease). Several different forms of paralysis also occur in children, commencing at an earlier stage than that at which infantile paralysis is usually seen, and due to lesions of the motor cortex of the brain, with secondary spinal degenerations. These may be due to infective conditions of the brain (polio-encephalitis) soon after birth, to lack of cerebral development, or injuries to the head and intracranial hæmorrhages occurring during birth, this latter condition especially occurring from the branches of the superior longitudinal sinus; such a hæmorrhage, therefore, usually occurs on one or both sides of the falx, and is especially liable to damage the motor centres of the legs. The result of these conditions may be a hemiplegia, a monoplegia, or a diplegia, the latter condition being known as Little's disease, the paralysis due to these lesions being of an upper motor neurone type, *i.e.*, spastic, with brisk reflexes and not very great wasting. The paralysis shows a considerable tendency towards a partial improvement, but the legs especially are liable to remain paralysed and spastic. The condition may be accompanied by mental deficiency, athetosis (involuntary movements) and deficient growth. The spasticity and muscular rigidity affecting certain muscle groups, if not prevented, will lead to gross deformities and contractures.

Other causes of spastic paralyses in children are congenital or acquired hydrocephalus or congenital syphilis.

Treatment. As before, this consists in the first case in attention to the general health and great care in the prevention of contractures and deformities. Any of the orthopædic measures described above may be found useful, and inasmuch as in limbs affected by this disease the muscular power is very much greater than in the cases affected by anterior poliomyelitis, the results of such operations as tendon grafting, tendon transplantation, tendon lengthening, etc., are much more favourable. Foerster's operation of resection of posterior nerve roots and Stöffel's operation on the peripheral nerves are specially suitable for these spastic cases.

The causes of deformities may be epitomised in the following table :—

(1) **Congenital.**
  - (*a*) Malformation or fracture of bones in utero.
  - (*b*) Intrauterine disease of the central nervous system, causing spastic palsies.
  - (*c*) Spina bifida, causing flaccid paralysis.
  - (*d*) Lack of liquor amnii and the presence of adhesions which may amputate or cause malpositions in utero.
  - (*e*) Hereditary conditions.

(2) **Acquired.**
  - (*a*) *Osseous.*
    - (1) Due to irregular growth or bone disease.
    - (2) Due to the malunion of fractures.
  - (*b*) *Nervous.*
    - (1) *Spastic palsy* due to upper neurone lesions, cerebral or high cord injury or disease.
    - (2) *Paralytic and flaccid palsy,* due to lower neurone lesions, anterior poliomyelitis, and injury or disease of the cord, or peripheral nerves.
  - (*c*) *Muscles, Fasciæ and Skin.*
    - (1) *Acute inflammation*—gonorrhœa and rheumatism.
    - (2) *Cicatrisation* after acute inflammation or trauma, *i.e.*, wounds and burns.
    - (3) *Muscle spasm* as the result of present or past joint disease or undue strain on a muscle.
    - (4) *Muscle weakness* as in myopathies, growing children and adolescents.
  - (*d*) *Compensatory.* To counteract other deformities or short limbs, etc.

Another and shorter classification of acquired deformities is as follows :—

1. *Nervous.*
   - (1) Paralytic
   - (2) Spastic.
2. *Inflammatory.*
3. *Static.*
   - (1) Adolescent.
   - (2) Compensatory.
4. *Traumatic.*
   - (1) Osseous.
   - (2) Nervous.
   - (3) Cicatrisation of soft parts.

DEFORMITIES OF THE LOWER LIMB

Congenital Dislocation of the Hip. This condition is not uncommon, and its cause is quite unknown, though deficient liquor amnii, a small uterus and amniotic bands have been suggested. The dislocation occurs before birth, though it is not known at what stage of development; very occasionally it appears to be hereditary, while it is more common on the Continent than in this country, more commonly unilateral than bilateral, and more frequent in girls than in boys (six to one).

Anatomical Features. These will depend to a certain extent upon whether the child has walked or not, the changes all being less marked in infants who have not put weight on their legs.

(*a*) At birth and in infants the acetabulum is imperfectly developed, being flat, shallow, too small to retain the head of the femur and occupied by fibrous and fatty tissues, The capsule of the joint is loose and large, the ligamentum teres thin and long. In some cases the whole half of the pelvis on the side concerned is contracted and underdeveloped. The femoral head is usually small and flat, being pressed against the innominate bone in the neighbourhood of the acetabulum. The neck of the bone is usually short and very often slightly twisted, while the angle it forms with the shaft may be slightly diminished or increased (coxa vara or valga). In some cases the femoral head and neck appear normal, while in all instances the head of the bone and the acetabulum are in the early stages covered with cartilage.

(*b*) In children who have walked other changes appear. Owing to the weight of the body the head of the femur becomes displaced further upwards on to the dorsum ilii and the capsule becomes stretched and thickened, very often with an hour-glass constriction about its middle. The head of the bone becomes still more deformed, while the acetabulum often becomes triangular in shape as a result of the feeble growth of its iliac portion, and it is shallow and without a definite socket. A new, very imperfect socket may form on that part of the dorsum ilii which is pressed upon by the head of the femur, such pressure occurring through the capsule, but no proper new bony socket is formed, as is seen occasionally in unreduced traumatic dislocations, because of the presence of this capsule. Sometimes several of these embryonic sockets are seen in different positions, showing where the bone has moved about. The head is usually displaced backwards and upwards, so that the pelvis will tilt forwards and give rise to lordosis. Changes occur in the muscles on account of the alteration in their length. The glutei and quadriceps are little altered, the other surrounding muscles are lengthened or shortened as the case may be ; the adductors in particular are much shortened. In many cases the development of the whole pelvis is very imperfect. As the dislocation is of the backward variety the thigh tends to become flexed, so that a compensatory lordosis develops.

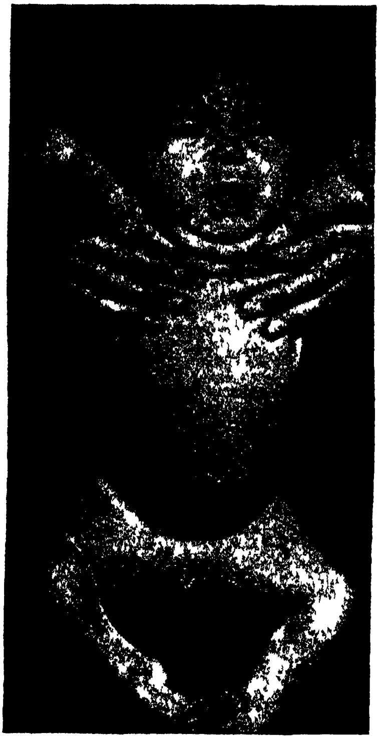


FIG. 348. Double congenital dislocation of the hips. Note shortening of the legs.

Clinical Features. The condition is not usually noticed until the child commences to walk, when the characteristic gait is noticeable, though occasionally the mother will comment on the breadth of its pelvis, the shortening of one leg, or may feel the head of the bone moving about under the buttock. Occasionally a very wide gap between the inner sides of the tops of the thighs will be noticed. When the child commences to walk, and it usually does so very late about the third year, its gait is of a peculiar character, and this and all the physical signs will depend upon whether the condition is unilateral or bilateral, the latter variety usually being the more difficult to diagnose and the one more commonly missed.

(*a*) *In unilateral cases*, if the child is stripped and watched when walking, it will be noticed that when the weight is put upon the affected limb the body dips down towards that side. The limb is shortened, so that the great trochanter is raised above Nelaton's line, and this shortening tends to increase until after a time it may amount to two or three inches. Walking is painless, while in addition it will be noticed that the buttock is prominent and the lumbar spine is held in a position of lordosis, this being especially marked when all the weight is put upon the affected side. The patient sometimes walks on his toes on the dislocated side, while the gluteal fold is higher and less marked on this side. The pelvis being tilted down on the affected side, a compensatory curvature of the spine is present above. The lordosis is partly due to the backward displacement of the head and partly to flexion of the hip produced by the ilio-psoas muscle. The movements of the hip joint are free, sometimes abnormally free, with the exception of abduction and complete extension. In some cases marked adduction with scissor-leg deformity is present, and it is common to see an additional crease present on the inner side of the thigh. In young cases it is possible to feel the head of the bone rotating under the upper part of the gluteal muscles, while on grasping the pelvis the leg can often be drawn up and down for an inch or two with a kind of telescopic movement. If forcible abduction is attempted, it is possible to feel and see the shortened adductors standing out like a hard, round cord, while an abnormal depression or softness can be felt in Scarpa's triangle due to the absence of the femoral head.

(*b*) *In bilateral cases* we have not the advantage of contrasting the two sides. Here the gait is very peculiar, being of a waddling character, the body descending and lurching towards each side as the weight is transferred from one leg to the other. The hollow of the back and the lordosis are still more marked, the abdomen and buttocks are prominent, while the legs appear short and the body long. The gap between the upper part of the inner sides of the thighs is often very noticeable just below the perineum, thus producing an appearance which may be known as "the female profile." After a time the deformity will become more marked as the ligaments stretch and the patient complains of fatigue and difficulty in walking. Recurrent attacks of synovitis are by no means uncommon in these joints on account of the strain borne by the ligaments and soft tissues. It is in the bilateral cases that the test of the position of the trochanter supplied by Nelaton's line is of special value.

Diagnosis is often difficult, especially in fat infants. The most important points, however, are the painlessness, freedom of motion, and the presence of the head in its abnormal situation, while an X-ray photograph should render the diagnosis certain; moreover, by showing the exact position of the head and the condition of the neck it will give assistance in treatment. Trendelenburg devised a test which consists in observing that when the patient stands on the affected leg the gluteal fold on that side rises in comparison with the fold on the opposite side, whereas in the normal hip it remains at the same level, and in coxa vara it descends below the sound side. It must not be forgotten that paralytic conditions of the muscles round the hip will closely resemble this condition.

The painlessness and lack of disability which are such marked features in early cases do not persist, as the longer the deformity lasts the more marked the disability becomes; the patient begins to complain of becoming easily tired and of pain and aching. An X-ray photograph is essential.

Treatment. If, as is unusual, the diagnosis is made before the child walks, *i.e.*, before the age of two or three, the head of the bone should frequently be drawn into the socket, *i.e.*, two or three times a day, and manipulated there; this will give it a tendency to resume its proper position. But in any case, up to the age of six, seven or eight years, **Lorenz's bloodless method** should be tried, and this frequently will be successful in unilateral cases, occasionally in bilateral ones. The most suitable age for the performance of this operation is between one and four; an anæsthetic is required, and the child is laid on its back with its legs over the end of a table and an assistant steadying the pelvis; the head of the bone must then be drawn down to the level of the acetabulum. In order to do this the adductor muscles usually will require kneading, stretching, rupturing or tenotomy, while all the muscles round the limb should be stretched by working the leg about and putting it through the most complete flexion, extension and rotatory movements possible. After this an effort is made to replace the head of the bone in its socket, which is often small and may be covered by the capsule. With the child in the same position the thigh is flexed to a right angle, then rotated outwards and fully abducted, the flexion continuing. Meanwhile the trochanter is pushed forwards by the thumb in order to try to guide the head of the bone into the acetabulum. Lorenz devised a wedge of wood covered with leather, which he placed behind the trochanter to push it forwards. This manœuvre may be repeated several times, and sometimes the reduction will be felt to occur with a jerk and a click.

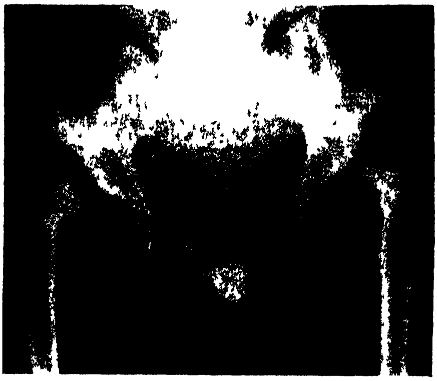


FIG. 349. X-ray showing double congenital dislocation of the hips.

The head has then to be kept in the socket, and this is done by putting the limb up in plaster of Paris with the hip in 90 degrees of flexion, 90 degrees of abduction, and no rotation. An X-ray photograph should be taken to see that the head has not slipped. It should remain in this position for two or three months, after which time a fresh plaster is put on each month, the abduction and flexion being slightly diminished at each renewal till the limbs become parallel again. In a unilateral case the child need not be kept in bed for more than a week or ten days. He is then encouraged to walk with a boot and high sole on the affected side and without a crutch; this will help to force the head of the bone into position. At the end of six months the plaster may be given up altogether as the soft tissues should now be firm, and massage and exercises should be started.

In bilateral cases both dislocations are reduced at once and both legs put in plaster in the position described (the " frog " position). This method of treatment gives about 50 per cent. of cures and much improvement in all cases.

If this method fails to reduce the dislocation, as is not infrequent, another attempt should be made after skin traction has been applied for a fortnight. If it then fails again an effort should be made to force the head forwards, so that it lies near the anterior superior spine under the rectus femoris or under the sartorius and tensor fasciæ femoris, thus converting the lesion into an anterior dislocation. This diminishes the tilting of the pelvis and the lordosis and improves the gait (*transposition of the femoral head*).

In older children, where the above procedure has failed or if redislocation occurs, reduction may be attempted by open operation. Fairbank has made an upper acetabular lip by means of a tibial graft, while Dott has devised an even more successful operation of the same type where the upper acetabular lip is formed by sliding down a part of the outer table of the ilium. The joint is opened from the front, or by turning up a flap containing the great trochanter, and the head of the bone and the acetabulum trimmed to fit each other, all tense structures which are hindering reduction cut and the head replaced. The limb is then immobilised in abduction and eversion with plaster of Paris for six weeks. Ankylosis of the joint will occur frequently, but the patient will walk well. Attempts have been made to peg the head of the bone to the ilium, but all such operations are serious undertakings. If all else fails, a supporting jacket of stiff leather running round the waist and down the thigh will improve the condition by diminishing the deformity and steadying the limb when walking. In adults it is usually best to leave the condition alone except, possibly, for a supporting jacket, or a raised sole and heel to the boot on the affected side.

COXA VARA

Two deformities are found to occur in which the angle that the head and neck of the femur should make with the shaft is altered. This angle should lie between 120 degrees and 140 degrees in normal individuals, the angle being rather wider in the child than in the adult. Any alteration of the angle which takes it outside these limits should be regarded as abnormal ; thus if the angle is less than 120 degrees, the condition is called coxa vara, and if more than 140 degrees, coxa valga.

Coxa vara is sometimes known as *incurvation of the neck of the femur*, and this angular alteration may occur either at the junction of the head and neck, in the neck itself, or at the union of the neck and the shaft. In most instances, in addition to the lessening of the angle already described, a certain amount of bending of the neck will occur in other directions also. Thus the head and neck of the bone, instead of passing obliquely upwards, become horizontal or even bent downwards ; in some cases the neck will become absorbed and practically disappear so that the head appears to be in contact with the shaft of the bone. The causes of this condition are several. In infants and children it is usually the result of rickets and is frequently bilateral, while at a later date, in children between the ages of ten and fifteen, it sometimes will be due to adolescent rickets. Any other condition which leads to softening of the bone, such as osteomalacia or osteitis fibrosa, also will give rise to it, while there is evidence that an excessive amount of walking or of carrying heavy weights also may cause it. A fracture of the neck of the bone which has united in imperfect position is a common cause, while it is often caused by a partial slipping down or separation of the epiphysis which constitutes the head of the bone, this displacement being equivalent to a bending of the neck of the bone. This latter form is seen especially in the case of persons between the ages of 10 and 18, when it is known as **adolescent coxa vara,** and is frequently the result of a minor injury affecting the limb, though the deformity does not show for some months or a year after the injury, when the epiphysis gradually shifts as a result of the weight of the body. The epiphyseal bone, weakened by the injury, yields under the body weight, so that the femoral head is forced up against the top of the acetabulum and held there while the neck slips upwards. The leg becomes rotated outwards, and this causes a prominence in front as the separated surfaces are rotated forwards. For this reason flexion can be increased by externally rotating the limb if this movement is possible. In many cases, however, the backward rotation of the trochanter mechanically prevents external rotation to any marked degree by actually locking against the posterior lip of the acetabulum. Here in time

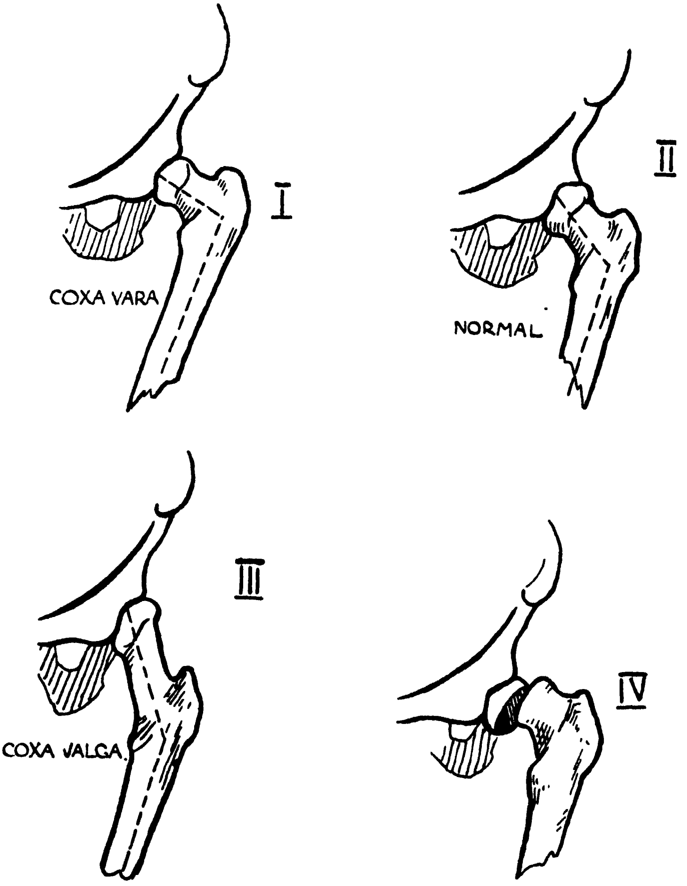


FIG. 350. I., II., III. Various angles formed by the femoral neck. IV. Slipping of the epiphysis of the head of the femur causing coxa vara.

a boss of new bone develops in some cases, as the result of the bones rubbing together, and this will further limit the abduction, which is already diminished by the upward displaced trochanter coming in contact with the posterosuperior acetabular lip.

The forms of coxa vara, therefore, may be regarded as ***rickety***, ***osteomalacic***, *traumatic*, and *the adolescent type*, which includes those due to displacement of the epiphysis and to adolescent rickets. In most of these cases, in addition to the bending of the neck, the femoral shaft becomes adducted and externally rotated. A *congenital variety* of the disease is rarely seen, due to the maldevelopment of the upper end of the femur. It causes no symptoms till the child begins to walk.

Clinical Features. The condition commences with pain and stiffness in the neighbourhood of the hip, while the patient is easily tired, commences to limp, and may complain of difficulty in kneeling, riding or separating the legs. As in other diseases of the hip, the pain is often referred to the knee. On examination it will be found that there is real shortening up to an inch or more, while the great trochanter is prominent, especially on flexing the thighs, and is displaced upwards and backwards. The limb will be found to be everted and adducted, this in the early stages being shown by the fact that abduction and internal rotation are limited; the former may be quite impossible, as the trochanter will catch against the acetabulum in severe cases. There is also considerable limitation of flexion. Wasting is very slight, much less than is seen in disease of the hip joint, though in its early stages the condition may resemble this; muscle spasm is absent, and the position of eversion and adduction is pathognomonic. In advanced cases the backward bending of the neck of the bone leads to much eversion, while at times the hip joint becomes more or less completely fixed and loses all its movements; this may be due to actual bony deformity or to muscular spasm.

It will be found that the patient compensates for the adduction of the hip as far as possible by tilting his pelvis, so that a compensatory scoliosis will be established (see p. 623). In addition to this compensatory scoliosis, in old-standing cases other secondary deformities will occur—thus pes planus, talipes valgus and genu valgum may result from the alteration of the line in which the body weight acts. The adolescent type, which is that most often seen, is usually unilateral and much more common in boys.

In bilateral cases the patient is very lame, and in severe instances the appearance is characteristic, as the legs are markedly everted and adducted so as to cross each other at the knee with a "scissor-leg" type of deformity. In the cases which come on as a result of slipping of the epiphysis following an injury, it will be found that the patient gives a history of an injury (often slight) months before, and that the condition has come on gradually since.

Diagnosis. Pain and limping are suggestive of many other conditions, such as tuberculous hip, sacroiliac disease, osteoarthritis and congenital dislocation. In coxa vara, however, the shortening is early and the wasting slight, while in tuberculous hip the shortening is late and the wasting marked. In coxa vara it is chiefly abduction which is limited; in osteoarthritis and tuberculosis all movements will be limited; in coxa vara there is no local swelling or tenderness, no telescopic movement, and freedom from pain when lying down. An X-ray photograph will settle the diagnosis. It must be remembered that osteoarthritis by causing deformity of the femoral head and diminution of the angle of the neck will give rise to a condition very similar to coxa vara, while old inflammatory diseases of the hip, or the pseudocoxalgia of

Perthes (see p. 545), will give rise to deformity of the head of the bone which, anatomically at any rate, closely resembles the above condition.

Treatment. This will depend upon the cause. In infants and small children, when it is due to rickets, the rickets should be treated and the child not allowed to put its weight upon its legs, and under complete rest the condition will improve. If due to other causes, and when the condition is early, complete rest in bed with massage and manipulation, and the application of an extension in the abducted position, will effect a cure ; the patient should then wear a caliper splint for six months to prevent a recurrence. Some surgeons advocate extension in the adducted position, and claim the functional results are much better after this. If the deformity is marked it must be corrected, and this should be done if possible by placing the patient in a plaster of Paris casing with the legs abducted as widely as possible and inverted. This must be done under an anæsthetic in order that the correction of the displacement may occur, and in many cases the shortened adductors will need stretching or cutting. The plaster casing should pass round the pelvis, up to the costal margin, and right down both legs to just above the ankles, the knees being slightly flexed. The plaster should be kept on for two or three months, when it should be removed and massage and exercises started. After two or three weeks of this the patient should commence to walk again, but he must wear a caliper splint for three or six months at least. Even though the condition is unilateral, both legs must be included in the plaster. Nearly all cases due to slipping of the epiphysis can be cured in this way.

In more severe or old-standing cases the bone must be divided by open operation. The subtrochanteric osteotomy of Gant is the best procedure, the adductor muscles being stretched or ruptured, the bone cut through just below the trochanter and the limb put up in plaster in abduction and internal rotation. The old osteotomy of Adams through the neck of the femur is seldom employed now. After these operations the limb will be shortened and a high sole will be required to compensate for this.

Coxa Valga. This is the opposite condition, in which the angle of the neck of the bone is increased to over 140 degrees. It is much rarer and causes few symptoms. It may be the result of fractures, rickets, minor degrees of epiphyseal separation, chronic forms of septic osteitis or paralysis of the neighbouring muscles from poliomyelitis. It is frequently accompanied by congenital dislocation, and may be due to absence of weight-bearing in the proper position. It is usually single and more common in boys than girls.

Clinically the condition is usually painless, though the patient walks in a peculiar manner rather resembling that of a congenital hip. The limb is lengthened, while the trochanter lies below Nelaton's line and is less prominent than usual. Adduction and internal rotation are limited, while the buttock may be flattened ; wasting and disability are very slight.

Treatment. In most cases little is required, though the length of the limb may be corrected by a high sole on the opposite side. In severe cases a transtrochanteric or subtrochanteric osteotomy will be necessary, the limb being placed in plaster of Paris in slight adduction.

Snapping Hip. This is an uncommon condition which is met with as a rule in young patients, more commonly women, in whom, when certain movements of the hip are performed, especially flexion combined with a slight amount of adduction and inversion, a sudden snap or crack is felt, which sometimes causes a little pain. The condition is usually congenital, but at times appears to result from an accident. On palpation, when this occurs, a deep rounded band-like structure will be felt which slips backwards and forwards over the great trochanter with a jerk as the limb moves. This is usually either the tendon of the gluteus medius, or a portion of the ilio-tibial band reinforced by the tensor fasciæ femoris. The condition has nothing to do with the hip joint itself.

In most cases no treatment is required and the patient is able to carry on, though it may interfere with athletic pursuits. If any treatment is required an incision must be made, the snapping structure exposed and identified by moving the hip about, and the tendon or band of fascia either divided and shortened or sutured to the bone in a new position.

Contractures of the Hip. Various forms of contracture of the hip, with gross deformity, are not uncommon. These may be the result of spasm and spastic conditions of various muscle groups, paralysis of other muscle groups, contracture of the soft tissues from injuries, burns, or when the hip joint has been held in a faulty position for a long time. In all these instances the tendency is for the joint to assume a position of marked flexion, adduction and internal rotation. If this condition is severe it actually will lead to pathological dislocation of the joint, when the head leaves the socket but does not pass outside the stretched capsule. The treatment required for these various deformities may be of many different kinds; tenotomy, osteotomy, plaster of Paris, arthrodesis, etc., all may be necessary.

However, the largest group of fixed deformities of the hip will be found to be due to ankylosis of the joint in a faulty position, usually the result of a previous tuberculous or septic arthritis. Here, again, the tendency is to flexion, adduction and inversion. In the treatment of such conditions open operation will be necessary, and will take the form either of an arthroplasty of the hip joint in an attempt to create a movable joint, or various osteotomies, such as Adams' or Gant's, which will correct the position of the limb, leaving the joint ankylosed (see p. 716).

DEFORMITIES AROUND THE KNEE

Certain congenital deformities are seen in this situation.

Congenital absence of the patella occurs, but is rare; it is usually associated with other abnormalities of the joint, and by itself does not give rise to any disability, so that it may not be noticed by patient or surgeon. When this deformity is present the quadriceps extensor tendon forms a thick band over the front of the knee and the tubercle of the tibia is unduly large.

Congenital dislocation of the knee joint is very rare and often accompanied by the above condition. It is sometimes persistent, and in other cases only appears at intervals as the result of certain movements. This condition is severe, and will lead to great disability; as no operative treatment is likely to benefit it, it will be necessary to fit the child with a supporting apparatus to steady the joint and prevent its slipping out of position when he walks.

Congenital Dislocation of the Patella. This is a not uncommon condition and occurs in two forms, the dislocation always being outwards:

(*a*) The *persistent* form, where it is present at birth, the patella lying permanently at the outer side of the joint. In this case the bone cannot be reduced, and when the joint is flexed it passes still further to the side.

(*b*) The *intermittent* form, where the patella is usually in its normal place, but at times becomes dislocated laterally, when the knee is flexed, and as the result perhaps of very minor degrees of violence (see also p. 506). In this case the dislocation will occur suddenly while walking, the patient will fall to the ground in pain and the bone will be felt lying at the outer side of the joint. The condition is most common in girls, and it will be found that, as well as being dislocated to the side, the bone is also rotated to a greater or less degree. At times it will stand out with its edge pressed against the femur, while complete rotation, so that its anterior surface is in contact with the bone, has been described. For some days after the incident the knee will be stiff, painful and full of fluid. When examining the joint in its normal condition it will be found that the range of movement of the patella is abnormally great in an outward direction, and in many cases it will be noticed that the external condyle of the femur is not properly developed, while the condition is frequently associated with a genu valgum (see p. 685). In other cases the capsule and ligaments are abnormally lax, while there may be some present or past paralysis of the quadriceps muscle. The condition shows some tendency to run in families (see also p. 506).

Treatment. When the dislocation has occurred it is easily reduced by extending the joint, and steps must be taken to prevent it recurring. In some cases a strong knee-cap or elastic kneelet will suffice, but in most instances operation will be necessary. Several operations have been devised for this purpose. The old method of tightening up the capsule by pleating it or excising portions of it on its inner side is of little use, as it stretches again. Other surgeons transplant the tibial tubercle, with the patellar ligament attached to it, to the inner surface of the tibia; or the patellar ligament may be split vertically and the outer half passed under the inner half after detachment from the tibia and be fixed to the inner side of that bone. The gracilis or portions of the sartorius tendon may be transplanted to the inner border of the patella or the patellar ligament. In some cases, where the condition is due to severe genu valgum, it will be sufficient to cure the causative condition (see p. 687).

Genu Recurvatum. This is a rare condition, in which the knee joint is hyperextended, the leg forming a curve concave forwards, which may be either present always or else only appear when walking. The condition is due to a variety of causes, and in all instances there will be considerable stretching of the crucial ligaments.

(*a*) In the congenital form it is probably the result of faulty position in utero, the legs being extended instead of flexed. This is probably made more marked by contraction of the quadriceps due to intrauterine fibro-fatty degeneration. In these instances the knee cannot be bent, the patella may be absent and other deformities present.

(*b*) It may be the result of paralysis of the extensor muscles of the thigh, the patient having to keep his legs hyperextended when walking to prevent the knee giving way, and this gives rise to the deformity in time, as the ligaments slowly stretch.

(*c*) It may be the result of alteration in the bony growth due to rickets, tuberculosis or other diseases of the epiphysis or to fractures or epiphyseal separations in this neighbourhood.

(*d*) It is not infrequently the result of disorganisation of the joint by Charcot's disease, tuberculosis, osteoarthritis, or of too long fixation in plaster of Paris with the joint fully extended, and spasm or contraction of the quadriceps extensor. Certain acrobats appear to have developed the condition as the result of practice.

Treatment. This will depend entirely upon the cause. In the congenital cases the joint must be flexed under an anæsthetic and fixed in that position in plaster of Paris for a prolonged period. If due to altered bony growth, splintage or osteotomy will be required in order to straighten the limb, while in cases due to paralysis or spasm a supporting apparatus will have to be worn, as the joint may be flail-like. This apparatus must have a lock at the joint, so that it can be locked in the extended position for walking and flexed when sitting down. In other cases operative procedure, such as arthrodesis of the knee or transplantation of certain of the hamstring tendons into the patella, will be required. Tenotomy of various shortened and spastic tendons may be required, or they may be lengthened or transplanted. Excision of the knee joint is sometimes required if bony fixity is present.

Contractures of the Knee. Fixed contractures of the knee joint are not uncommon, and may be due to contraction of the soft tissues from burns, injuries, suppuration in the popliteal space, etc. They are, however, more commonly due to ankylosis of the knee joint, which is described in Chapter XIX.

The opposite condition of "flail-knee" is sometimes seen as a result of severe anterior poliomyelitis; this is really a very severe form of genu recurvatum, and its treatment is the same (see p. 684).

Genu Valgum. This is a deformity of the knee, in which the angle which the femur makes with the tibia is altered. A line drawn from the central point of the femoral head to the midpoint between the malleoli in the normal joint should pass through the centre of the knee joint, and if this line passes outside the centre of the knee joint the condition is known as genu valgum or "knock-knee." The condition is therefore an abduction of the legs away from the middle line, so that the knees tend to knock together in walking, while if the legs are kept straight and the knees allowed to touch with the patellæ forwards the malleoli will be separated by a considerable interval. The condition may be unilateral or bilateral, while one leg occasionally will exhibit genu valgum and the other leg genu varum (see p. 688).

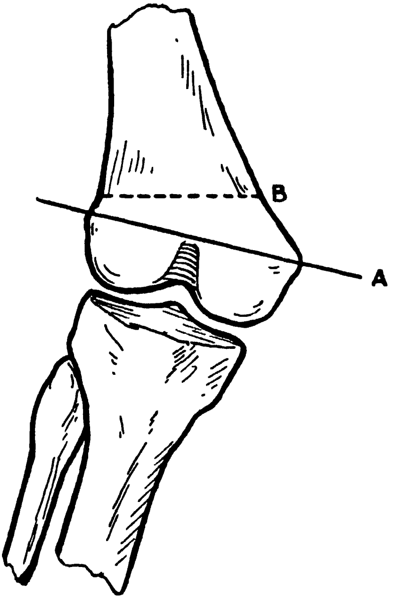


Fig. 351. Genu valgum. A is a line passing through the epiphyseal line. B is the line where an osteotomy should be done to avoid the above.

Anatomically it will be found that changes occur both in the upper end of the tibia and lower end of the femur, especially in the latter. Thus the inner condyle of the femur appears to be elongated, but is not broadened in an antero-posterior direction, while the outer condyle appears shortened and atrophied. On making a section of the bone it usually will be seen that the epiphysis is unaltered, and that the diaphysis is lengthened on its inner side and shortened on its outer side, so that the epiphysis is set at an angle on the shaft, thus giving rise to the appearance described above. As there are no corresponding changes in the antero-posterior direction, it will be seen that the deformity disappears when the knees are flexed, unless the condition is associated with bending of the tibial shafts, as sometimes happens. It is possible that the deficient growth of the outer side of the diaphysis is due to the unusual distribution of weight on this part of the bone. Irregular ossification is sometimes seen in the epiphyseal line. The cartilage on the outer condyle and the external semilunar cartilage are thickened, the ligaments and muscles on the inner side of the joint are stretched, while those on the outer side are often contracted, shortened and displaced laterally. All the tendons tend to pass to the back of the joint instead of being at the side, while the structures in the popliteal space are displaced outwards, as also are the quadriceps tendon and the patella. The joint is weak, hyperextensible, and often contains an effusion.

Similar changes in a lesser degree will be found in the head and the upper third of the tibia.

In addition to this, a group of secondary and compensatory deformities are present. The feet are displaced outwards and there is a tendency to pes planus and talipes valgus (see pp. 694, 698), while the neck of the femur becomes shortened, and its angle is diminished (coxa vara). The lower half of the tibia and fibula are sometimes bent, while in severe unilateral cases the pelvis will be tilted and there will be a compensatory scoliosis ; the tibia as a whole usually becomes rotated outwards also.

In most cases, therefore, this condition is due to irregular growth in the epiphysio-diaphyseal line of the femur or tibia, or both. In a great majority of cases it is the result of *rickets*, and this variety is especially seen in young children. Once the deformity has started to occur the line of the body weight is thrown out, so that it is transmitted chiefly to the outer part of the joint, and thus the deformity tends to increase as the leg becomes more and more abducted. Rickety curves in the femur or tibia will increase the tendency to the condition.

In adolescence what may be called a *static* form of the disease occurs. Here, as the result of feeble health, relaxed muscles, much standing and weight carrying, the slight angle which the femur normally makes with the tibia permits undue strain to be thrown upon the internal lateral ligaments, especially if the patient is in the habit of standing in a faulty position with the feet abducted. The lateral ligament thus may become strained and yield, while the muscles become tired and weakened. Once the condition has started to develop, the body weight tends to make it progressive, and the bony changes in this variety follow as secondary and compensatory conditions. The outer condyle atrophies from increased pressure and the inner one becomes overgrown. In some cases the condition is secondary to other deformities, such as flat foot, talipes valgus, coxa vara, shortening of the leg or scoliosis.

There are other and rarer causes. The condition is occasionally *congenital* as the result of a faulty position in utero, while a *traumatic* form is seen as the result of fractures near the knee joint, dislocation of the knee with tearing of the ligaments, or damage to or separation of the epiphyses. Various forms of *muscular paralysis*, usually spastic forms, will give rise to it, whilst osteomyelitis of the femur and inflammatory or degenerative diseases of the knee joint may be causes. It is said that excessive riding in long-legged people will give rise to it.

Clinically it is found that in infants the condition appears spontaneously soon after they commence to walk, whilst in older patients (static cases), when the disease is commencing, there is pain down the inner side of the knee in the neighbourhood of the internal lateral ligament. In the common cases, due to inequality in the femur, the deformity disappears and the malleoli can be made to meet when the knees are flexed, but this disappearance does not occur if the tibia is seriously affected. The joint is usually loose and permits a certain amount of hyperextension, lateral movement and rotation, while the affected limb is rather shorter than the other. It will be found that the patient walks with a curious waddling gait, keeping the legs partly flexed and separating his knees as he walks. The boots become more worn down on the inner than the outer side, and in some cases a boss or knob of bone is found on the inner surface of the tibia near the insertion of the sartorius tendon and probably due to strain of this tendon.

The X-ray appearances are characteristic: the epiphyseal line is seen to be irregular, broadened and sloping, while the changes of rickets may be seen (Chapter XVIII., p. 560). Rickety changes frequently will be seen in other parts of the body, and search must be made for other associated deformities. The condition is more common in boys than in girls, and more commonly bilateral than unilateral.

Treatment. This will depend entirely upon the cause, while it should be remembered that in children under five, whatever the cause, there is considerable tendency for the bones to grow straight if the child is kept completely off his feet.

In rachitic cases the rickets must be treated by appropriate measures and the child must not be allowed to put his foot on the ground. This is easily effected by fastening light splints down the outer side of the limb, which extend three or four inches beyond the feet. At the same time, by drawing the knee towards the splint with strong bandages, the deformity may be decreased, and this should be accompanied by massage and manipulations tending to bend the legs straight. In other cases plaster of Paris may be applied under an anæsthetic after straightening the limbs as far as possible and the plaster renewed every few weeks while the deformity is gradually reduced. In mild cases this will produce a cure in the course of six or eight months.

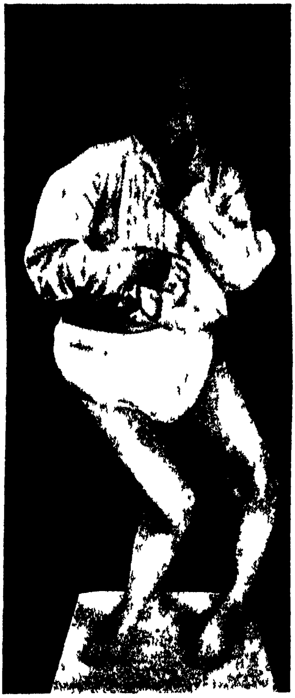


FIG. 352 Genu varum and genu valgum due to severe rickets. *Genu Extrorsum.*

In severe cases, *i.e.*, where the separation between the malleoli is over 10 inches, or in older children, the limbs should be straightened by means of Macewen's supracondylar osteotomy (see p. 716). The femur is divided transversely half an inch above the inner condyle through a half-inch longitudinal incision just in front of the tendon of the adductor magnus. This is done with an osteotome, the final division of the bone being made by fracturing it. Some operators prefer an incision on the outer side of the thigh and divide the femur from the outside with a saw. The limb is then straightened and put up at once in plaster of Paris for six or eight weeks, after which massage and exercises are commenced. In a few severe rickety cases the tibia may need division as well, just below the tubercle. It is not wise to operate upon both legs on the same occasion in a bilateral case, as this is too severe a proceeding.

In static cases the bony deformity is not usually sufficient to need operation. Here the patient suffers from pain, tiredness and weakness and the treatment should consist in tonics, fresh air and general measures, combined with absolute cessation of weight bearing and massage to the limb. After some weeks or months of this rest he may commence to walk again, but must wear a suitable apparatus to relieve the knee from strain. This should consist of an outside iron fixed to the heel of the boot with a pelvic band, a joint at the knee and padded straps round the limb at intervals, with a broad band passing round the internal condyle to draw the femur outwards.

Very slight cases in older children can be corrected usually by means of raising the inner side of the sole and heel of the boot and giving them exercises to strengthen the knee and force it outwards during flexion.

Genu Varum (Bow Leg). This is the reverse of the preceding deformity,

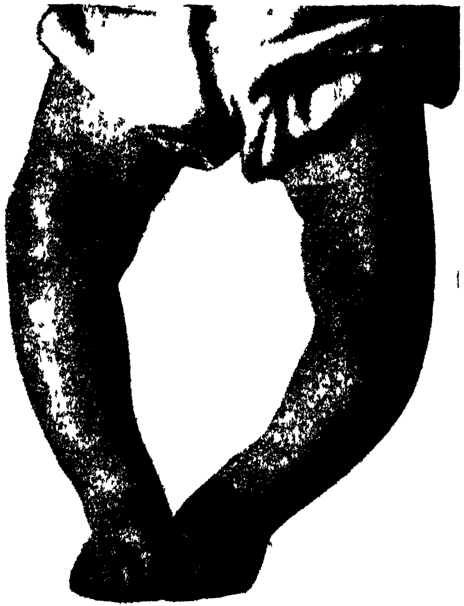


FIG. 353. Double genu varum due to rickets.

where it is found that the leg joins the thigh at an angle with its concavity in the medial direction, so that when the ankles are in contact the knees are widely separated. It is less common than the previous condition, almost always bilateral, and in most cases due to rickets. Some instances are the result of trauma, especially affecting the tibial head or femoral condyle, while in other cases it is the result of excessive riding, where it is especially seen in jockeys and small men with short legs. Both the femur and tibia are affected, the latter bone being chiefly involved. The condition gives rise to very few symptoms and is usually quite painless, while the patients who suffer from it are particularly strong and sturdy on their legs. It is, however, ugly and causes the patient to look short and stunted.

Occasionally it will be found that one knee is in a state of genu valgum and the other in genu varum (*genu extrorsum*).

Treatment. This is similar to the treatment of genu valgum.

Deformities of the Tibia and Fibula. Bowing and bending of these bones are by no means uncommon in children. The condition is nearly always bilateral, symmetrical and sometimes accompanied by other deformities. In most cases it is due to rickets, though occasionally it is caused by congenital syphilis. It usually will be found that the rickety tibia has its curve in its lower half and in a lateral direction, as well as being partly antero-posterior, while the bone is not thickened or rounded. The syphilitic tibia, on the other hand, is curved throughout its whole length, almost entirely in an antero-posterior plane, and has its border thickened and rounded (see p. 556). These curves may commence before the child walks, but will increase rapidly when he puts his weight upon the limbs. Often the femora are involved as well, so that a condition of marked bow leg arises, while in some cases the curves are sufficiently sharp to resemble a fracture. Flat foot and coxa vara often will be present as well, while the condition may lead to genu recurvatum. In very severe cases the patient will be sufficiently small and stunted to be regarded as a rickety dwarf. Other signs of rickets or syphilis are often to be detected. It must not be forgotten that somewhat similar deformities will occur at a later age in osteitis deformans, osteomalacia, or as the result of malunited fractures ; these are met with in adult life.

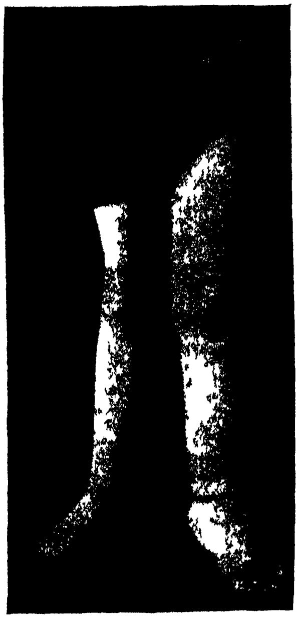


FIG. 354. Hypertrophy of one leg in a girl of fifteen. The cause of this was unknown.

Treatment. In children under the age of seven and in cases where the deformity is only slight, there is no doubt that the bones gradually will grow straight if the child is kept completely off his feet, if massage and manipulations are applied to the bone and such conditions as rickets or congenital syphilis treated. The patient is best kept off his feet by well-padded splints projecting beyond the feet, to which the limb is firmly bandaged. In children over seven and in more severe cases operation may be necessary, but this should be avoided if possible It should never be undertaken until all signs of active disease have passed away. Osteotomy is better than osteoclasis, and in severe cases the osteotomy will have to be cuneiform, a wedge-shaped portion of bone being removed. This will have to be followed by prolonged after-treatment, splintage, massage, etc.

Osteotomy always should be performed as high up the tibia as the deformity will permit, as much better union will be secured here and the lower fragment is easier to control.

Congenital Absence of Bones. These are rare conditions. The tibia is occasionally absent, either completely or more rarely partially. This abnormality is usually unilateral and gives rise to a useless limb, short and bent, with the foot in a marked position of equino-varus. If the upper portion of the bone is absent the fibula will be found to articulate with the femur. No known theory, developmental or otherwise, satisfactorily explains these conditions. Absence of the tibia is frequently accompanied by absence of the great toe and its metacarpal bone. The fibula also may be congenitally absent, so that there will be no external malleolus and the foot takes up the position of extreme valgus. Often in association with this condition there is marked bending of the tibia, while the inner two or three toes and inner half of the foot are frequently absent. In both these deformities growth of the limb is deficient and the deformity becomes more and more marked as the child grows. An X-ray photograph always should be taken to see which and how much of the bones are absent.

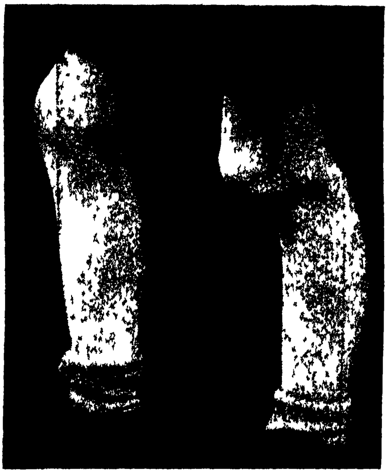


FIG. 355. Congenital absence of the head of the tibia.

Treatment. In the treatment of these conditions great ingenuity may be required. Bone grafting may be employed or the bone which is present may be partly transplanted into the position of the bone which is absent, either by means of splitting it or without damaging it. The deformities of the neighbouring joints will require correction, and in many cases something will have to be done to stabilise these joints, such as fixing the head of the fibula to the femur, or splitting the lower end of the tibia to receive the astragalus. Shortening or lengthening of tendons or fasciæ will be required, while in many cases any deformity present will need overcorrection. Irons and supporting appliances will be found useful, while amputation should be avoided if possible.

DEFORMITIES OF THE FOOT

The foot consists of three separate arches which are provided to permit of a sufficient degree of elasticity between the various bones, to ensure that in walking, jumping and running no heavy shocks will occur as the body weight falls on one or other foot. The springiness of these arches is assisted by the numerous little bones held together by muscles and ligaments which enter into their formation. The arches are supported partly by the way in which the bones are fitted together, partly by the ligaments and partly by muscles, especially those which have long tendons running along the sole of the foot. The arches are three in number :—

(*a*) The longitudinal arch (internal), which forms the arch of the instep and keeps the skin of the foot clear of the ground on the inner side. This varies greatly in degree, and it is supported partly by the inferior calcaneo-navicular ligament and also the tendon of the tibialis posticus, the plantar fascia and ligaments and short muscles of the foot.

(*b*) The longitudinal arch (external), which is very slightly marked.

(*c*) The transverse arch, which runs across the foot and raises the central metacarpal bones slightly from the ground. It is dependent for its integrity upon the two longitudinal arches, and the peroneus longus tendon.

Talipes. A large group of deformities of the foot are met with in connection with the ankle and tarsus. These may or may not be combined with other deformities affecting the metatarsals and toes. The term " talipes " is applied to all these deformities which affect the posterior part of the foot, *i.e.*, the neighbourhood of the ankle and mid-tarsal joints. It may be due to nervous diseases, leading to muscular spasm or paralysis or to ligamentous or osseous causes. It is popularly known as " club foot," and consists of many different varieties, which go by the names of talipes equinus, talipes calcaneus, talipes valgus, talipes varus, the pure and uncomplicated forms and the combinations of talipes calcaneo-varus, calcaneo-valgus, equino-varus and equino-valgus. The deformities affecting the front half of the foot are known by the expression pes, *i.e.*, pes cavus, pes valgus. Of these forms of talipes some are common and some are very rare, while they may be congenital or acquired.

(*a*) *Congenital Talipes.* This is a common variety, which tends to run in families and to be transmitted from one generation to another ; it is said to follow the Mendelian law. It is sometimes accompanied by other deformities, such as hare-lip or spina bifida, in the latter case the spina bifida probably causing the talipes by nervous involvement. In some instances it is the result of imperfect bony development, while in other cases it is thought to be the result of malposition in utero caused by a small uterus or deficient liquor amnii, and it is certainly true that the foot in the baby can easily be moulded into abnormal positions. The condition is more common in boys than in girls, and is more often bilateral than unilateral.

(*b*) *Acquired Talipes.* This variety is due to many different causes which affect the various muscles and tendons in this situation. Thus there is a large group of paralytic cases where certain muscle groups are paralysed and permit over-action of opposing groups. This is most commonly due to anterior poliomyelitis, though it is often seen as the result of lesions of important peripheral nerve trunks, such as the external and internal popliteal nerves. In certain diseases of the brain and spinal cord a spastic condition of individual muscle groups is set up, which causes the deformity by overcoming the weaker opposing muscles. Another important group of cases is the result of scarring or contraction of the muscles, tendons or fasciæ following injury, and suppuration or disease of the near-by bones, while fibrous contraction of muscles may result from chronic muscular diseases. Over-growth or altered growth of the tibia or fibula as the result of epiphyseal separations or inflammation is also a not uncommon cause, while in limbs which are shortened a compensatory talipes may occur, which usually comes about in order to increase the effective length of the limb. Malunited Pott's fractures give rise to one of the most severe forms. Talipes equino-varus and talipes equinus are by far the commonest varieties seen.

Talipes Equinus. In this variety the heel is drawn up so that the toes point downwards, and the patient will probably walk upon them. It is practically never congenital and is usually the result either of spastic paralysis of the calf muscles or a paralysis of the dorsiflexors, due to poliomyelitis or peripheral neuritis. It is sometimes the result of wounds of the calf muscles where extensive suppuration and scarring have occurred, or where extensive muscular excisions have been performed for gas gangrene. It occurs as a compensation when the limb is shortened as the result of hip disease, after injuries and diseases in the neighbourhood of the ankle, and especially in those cases where the foot has been allowed to remain in a dropped position for a prolonged period, as when improperly splinted during the treatment of a fracture or when pressure by the bed-clothes upon the toes has been permitted. In slight cases the foot can be raised to a right angle and no further, but in more severe cases the heel is drawn up and the patient walks on the balls of his toes. In very severe cases the toes are flexed and the foot assumes a position of pes cavus (see p. 697), so that the patient actually may walk upon the backs of his toes. Poliomyelitic cases are usually unilateral, and as in all cases of talipes due to this cause, the foot is cold, blue, shrunken and atrophic. Spastic cases are usually bilateral and accompanied by the excessive flexion with pes cavus described above. Painful corns, callosities and adventitious bursæ, which become inflamed, will form above the pressure points, while in severe unilateral cases the patient finds difficulty in walking

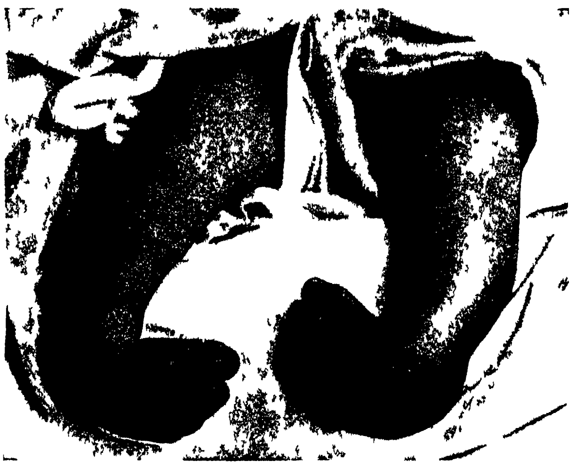


FIG. 356. Congenital talipes equino-varus in an infant; the varus part of the deformity is most marked.

owing to the lengthening of the affected limb. Anatomically it will be found that the astragalus projects forwards on the back of the foot, becoming very largely separated from contact with the tibia, while the os calcis is drawn up behind and may come into contact with the fibula and tibia. Flexion of the foot also occurs at the mid-tarsal joint, while contraction and shortening of the plantar fascia, the posterior ligament of the ankle and the ligaments and muscles of the sole of the foot, together with the long flexor tendons to a lesser degree, is marked.

In many cases of talipes equinus, especially those due to poliomyelitis, a varus element due to paralysis of the peronei is present also. For treatment see p. 695.

Talipes Equino-Varus and Varus. Talipes varus alone is exceedingly rare, and as the condition is almost always one of equino-varus, these two will be described together.

In talipes varus the foot, especially its anterior half, is inverted and adducted so that the patient walks on the outer side of the foot, while, as already stated, in nearly all these cases an equinus element is added, causing the toes to point slightly downwards.

Talipes equino-varus is the commonest form of congenital club foot met with.

(*a*) The *congenital cases* are usually bilateral, the heel being found drawn up and the front half of the foot turned inwards, showing a marked concavity towards the medial side. There is marked internal twisting and angulation of the head of the astragalus and usually a well-marked transverse crease in the skin crossing the sole about at the level of the mid-tarsal joint, while the outer border of the foot on which the patient stands and walks is convex and covered with thick skin and callosities. The weight is borne chiefly on the fifth metatarsal and in severe cases even upon the dorsal surface of the cuboid. Secondary contraction of the soft tissues of the sole of the foot occurs and increases the deformity. In children who have not walked the deformity is usually slighter, corns and callosities are absent, and the creasing of the skin is often not apparent. On the other hand, in those who have walked the deformity becomes very much worse, the tarsal bones standing out prominently upon the dorsum of the foot, whilst the head of the astragalus becomes very obvious. Adventitious bursæ and callosities form over the pressure points, the former frequently becoming inflamed and suppurating. There is no paralysis of the musculature of the leg, but nevertheless a marked disuse atrophy occurs, so that the patient walks in an ugly and laborious manner.

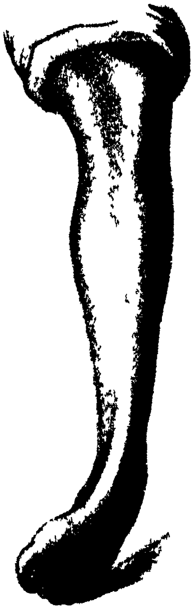


FIG. 357. Foot in a marked varus position.

In advanced cases, and especially in adults, definite changes occur in the bones, especially in the astragalus and os calcis. Apart from the fact that they are rotated and displaced, the neck of the astragalus becomes elongated and inclined inwards; the scaphoid is displaced to the inner side of the astragalus, and the mutual relations and articulations of all the tarsal bones are greatly altered. In some cases the lower third of the tibia becomes bent also. With regard to the soft tissues all those on the inner side of the foot are shortened, especially the inferior calcaneo-navicular ligament and the internal ligament of the ankle. The tendo Achillis is shortened and the extensor tendons on the dorsum of the foot are displaced inwards. The presence of the transverse crease on the sole of the foot is said to be due to contraction of the plantar fascia and to be characteristic of the congenital form of talipes.

(*b*) In *acquired talipes equino-varus* the cause is usually poliomyelitis or spastic conditions of the muscles. Peripheral neuritis, progressive muscular atrophy and lesions of the external popliteal nerve also will give rise to it. This form is usually unilateral, and gives a history that it has come on two or three years after birth as the result of a definite illness instead of appearing at birth. In the congenital form the circulation is good, but in the paralytic form the limb is cold, blue and wasted, while the electrical reactions will be found to be almost completely absent in the paralysed muscles concerned. Atrophy and diminished growth are much more marked in the paralytic than in the congenital variety, the limb may be shorter than its fellow, and pressure sores may form. It is said that creases are absent from the skin in the paralytic variety. In early acquired cases the limb is usually flaccid and the deformity capable of correction at first by manipulation. After a time, however, the opposing muscles become shortened and contracted, and a secondary shortening of the soft tissues, such as fasciæ and ligaments, sets in, thus rendering the deformity permanent. The same changes occur in the bones and their mutual relations as have already been described.

For the treatment of this condition see p. 695.

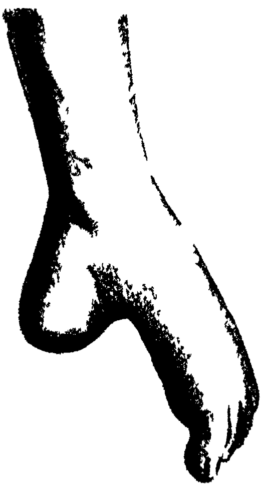


FIG. 358. Talipes equinus, showing also a claw foot.

Talipes Calcaneus. In this condition the toes are drawn up from the ground and the patient walks upon his heel. It is a rare deformity, and more commonly will be seen combined with either a varus or valgus element. As before, it may be congenital or acquired.

(*a*) In the congenital form it is usually bilateral, and when the patient walks the heel alone touches the ground, while if an attempt is made to force the sole downwards the contracted and shortened extensor tendons stand out prominently. Changes in the bones, their mutual relationships, and in the soft tissues will be found as in the previous variety. This variety is often found in conjunction with spina bifida.

(*b*) The acquired form is usually due to poliomyelitis or division and overstretching of the tendo Achillis. In these cases there is nearly always a flexion towards the sole of the anterior part of the foot (pes cavus), giving rise to a somewhat different appearance and tending to minimise the deformity, this flexion of the front part of the foot being due largely to the weight of the toes, and to contraction of the plantar fascia and short muscles of the sole. A variety of this deformity, artificially produced, is seen in the feet of Chinese and Japanese ladies.

For the treatment, see p. 695.

Talipes Valgus. A true talipes valgus is seldom seen, although an advanced degree of flat foot (see p. 698) will imitate this condition closely. Talipes valgus consists in an abduction and eversion of the foot due to the yielding of the internal longitudinal arch. It is practically unknown as a congenital condition, and is more commonly seen in the form of talipes calcaneo-valgus. It is usually the result either of poliomyelitis or a spasm of the peronei muscles. The sole of the foot becomes flattened out, loses all creases, the longitudinal arch disappears and the inner border of the foot comes in contact with the ground. A few cases of this condition are due to absence of the fibula (see p. 690), while severe cases are seen which are the result of mal-united Pott's fractures.

For treatment, see below.

Talipes Calcaneo-Varus. This is the rarest form of talipes there is. It is never congenital, but always due to one of the causes of acquired talipes mentioned above.

It will be seen, therefore, that the diagnosis of the variety of any particular case of talipes is usually obvious on looking at the foot. It may be, however, more difficult to determine whether it is congenital, paralytic, or spastic. It must be remembered that in congenital cases the condition is present from birth, usually symmetrical, the limb is well nourished, not stunted, cold or blue, and that the deformity resists any attempt to correct it. In paralytic cases the limb is cold, clammy, bluish, shrunken and atrophied, with trophic lesions and perforating ulcers, and there is usually a history of the condition coming on suddenly some months or years after birth, while the muscles are flabby and show characteristic electrical reactions. In the early stages the condition is easily correctible. In spastic cases spasm of certain muscles can easily be detected ; the muscles are little wasted and not paralysed, while the reflexes are brisk.

Treatment. This will depend upon the cause and the variety of the talipes. It must be remembered that in all cases a cure will take a very long time to produce.

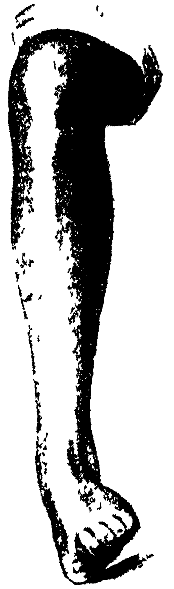


FIG. 359. Foot in a marked valgus position.

(*a*) *Congenital Cases.* Here the deformity must be corrected as soon after birth as possible by daily manipulations, while the limb should be fixed on splints to keep it in the corrected position, and, if possible, in an overcorrected position. This is best done by light plaster of Paris splints, aluminium splinting, or even strapping and bandaging. At the same time the limb must be massaged and douched to increase its vitality. In many cases, if this is persisted in from the first, by the time the child commences to walk the deformity will be very largely overcome, and when he begins to walk the weight of the body will, at any rate in the cases of talipes equinus, varus and equino-varus, assist to correct the deformity, but the manipulations, massage and splintage must be persisted in for a long time. In severe cases repeated applications of plaster of Paris, each producing a little improvement, may have to be indulged in, while in more severe cases still, and in late stages which have not been treated early, various operative procedures will have to be undertaken. Before the condition is completely cured (and this is nearly always possible) the child probably will have to be under observation and treatment for four or five years.

Thus, in *talipes equino-varus* and *equinus*, tenotomy of the soft parts may have to be performed. The tendo Achillis, plantar fascia, the internal ligament of the ankle, the calcaneo-navicular ligament and certain other tendons may need section. The equinus and varus elements of the condition are best dealt with separately and on separate days; after the necessary sections of soft tissues the deformity may then be corrected forcibly by pressure, either with the hands or by a mechanical wrench, and the foot put up in plaster of Paris as far as possible in an overcorrected position. In some instances this correction can be performed by wrenching under an anæsthetic without any actual cutting. Plaster of Paris fixation will have to be maintained for at least six weeks, and it must be followed by adequate massage and exercises. Operative measures of this kind are best performed when the child is about a year old, as he is then able to stand the shock, and it is not likely that bony deformities will have occurred. In later cases and in elder children, apart from the contraction of the soft tissues, definite bony deformity will have occurred, so that operation upon the soft tissues alone will then not be sufficient. In cases which come up for treatment for the first time at the age of two years or older this is almost certain to be so. In these cases the resection of a wedge from the tarsus, the wedge having its base on the outer side, or excision of the astragalus may be necessary before the deformity can be corrected. Cuneiform tarsectomy is best performed by a curved incision on the outer side of the foot through which adventitious bursæ are removed and the extensor tendons held aside. A narrow wedge is then removed by means of a chisel without paying any attention to the position of the joints and sufficiently wide to allow the foot to be brought into proper position easily. The foot must then be put into plaster of Paris for two months, this to be followed by massage and exercises. The result of this operation is a foot which is firm and straight, though somewhat stiff and shortened.

Another operation which has been performed for this condition in young children before complete ossification of the tarsal bones has occurred, consists in removing with a gouge the ossifying nuclei of the tarsal bones, leaving only a bony or cartilaginous shell. The foot can then be moulded into position and fixed with plaster of Paris (Ogston).

In the case of *talipes equinus,* section or, better, lengthening of the tendo Achillis and of the flexor tendons and plantar fasciæ probably will be all that is necessary. This may be assisted by excising an oval area of skin from the front of the ankle. But here again in very severe cases bone will need removal, and this is here best effected by excision of the astragalus.

In *congenital talipes calcaneus* again manipulations soon after birth will be required, while in severe cases it may be necessary to lengthen the extensor tendons or excise and shorten the tendo Achillis. It is sometimes advised that the tubercle of the os calcis with the tendo Achillis attached to it should be detached from the bone and pegged on to the os calcis again lower down.

(*b*) *Acquired Cases.* In acquired cases of talipes the treatment will depend naturally upon the cause, and in most instances if proper treatment is adopted early the condition can be prevented completely.

In *paralytic talipes equino-varus* the non-operative methods of splinting and manipulation already mentioned often will be beneficial, while tendon transplantation will be required in the more severe cases. Thus the tibialis anticus may be transplanted into the base of the fifth metatarsal, or into the cuboid, but this is only available in the cases where the paralysis is not very widespread; in those severe cases where practically all the muscles are weak, the ankle and midtarsal joints had better be ankylosed or tendon fixation employed to steady the joints, the tendons thus used becoming transformed into accessory ligaments. The tibialis anticus tendon and peroneus longus may be employed in this way. If talipes equinus is secondary or compensatory, as when the limb is shortened or in cases of hip disease, it is best not interfered with, while in many of the acquired cases prevention of the condition could easily have been achieved if treatment only had commenced early enough. In acquired cases, as in congenital cases, tenotomy, section of soft tissues, and even bony excisions often will be necessary as accessory measures.

In many paralytic cases the use of specially-made boots and suitable leg irons and supports will be of the greatest benefit.

Spastic talipes equino-varus is uncommon, and here lengthening the shortened tendons of the muscles will be of the greatest benefit.

In *paralytic talipes calcaneus* it may be of advantage to transplant the tendons of the peronei or extensor longus digitorum into the back of the os calcis, while in some cases the tendo Achillis may be shortened. If the ankle is completely flail-like it should be fixed. The cavus element which is frequently present in this deformity can be corrected by resecting a wedge from the tarsus with its base upon the upper surface of the foot, and placing the foot in a position of overcorrection in plaster of Paris.

Talipes valgus will be treated in the same way as advanced pes planus (see p. 700).

In very severe cases of talipes, where other methods have failed and septic bursæ and trophic lesions are present, amputation may be advisable.

It must be remembered that after any of these operations or corrections, massage, exercises, electrical treatment for the muscles and the wearing of a corrective and retentive apparatus must be persisted in for at least a year or two, and the great principle of the overcorrection of deformities must be carefully studied. As using such a limb is one of the most rapid methods of restoring function, power and circulation, the patient should be encouraged to walk upon it as soon as possible.

Pes Cavus (Pes Arcuatus, Claw Foot). In this condition, which is nearly always acquired, the balls of the toes are brought near to the heel, so that the foot is shortened and the longitudinal arch of the foot is exaggerated and there is an increased dorsal convexity. The instep is abnormally high, while the toes are contracted and drawn up, the interphalangeal joints being plantar-flexed and the metatarsophalangeal joints dorsiflexed, the toes thus assuming roughly the position of hammer toe. Callosities form beneath the heads of the metatarsal bones, while the plantar fascia and short muscles are contracted. Pain in the instep is severe (metatarsalgia, *q.v.*), while tender bursæ and callosities form, and it is very difficult to get properly fitting boots. In very severe cases the foot becomes inverted and walking almost impossible. This condition is nearly always found in combination with a paralytic talipes equinus or calcaneus; in many cases it is the result of paralysis of the lumbricals and interossei, while it may be that in some cases it is the result of the alteration of the line of action of the body weight produced by the talipes. A few cases are undoubtedly congenital, but the condition usually occurs in association with diseases of the spinal cord, such as spina bifida, Friedreich's ataxy, anterior poliomyelitis, and progressive muscular atrophy of the peroneal type. In some of these spinal diseases the pes cavus will be the first sign or symptom noticed. Rheumatoid arthritis of the tarsal joints is responsible for other cases.

Treatment. In the early stages correction of any talipes present will be sufficient. This may be assisted by lengthening the Achilles tendon and putting the foot in plaster of Paris in a position of overcorrection. This is to be followed by exercises and massage and the wearing of boots with no heels and a bar placed across the sole just behind the heads of the metatarsals ; the object of this is to keep the weight off the toes. In more severe cases, where the first metatarsal head is prominent, the tendon of the extensor hallucis may be passed through a transverse hole in the head of the first metatarsal and fastened back upon itself so that it lifts the head of the bone, while the contracted structures, such as the plantar fascia, will need section. The foot is then put in plaster of Paris in an overcorrected position. In more advanced cases still, where all the metatarsal heads are prominent and painful, the short muscles and ligaments of the toes may be slid forward after detachment from the os calcis, or about an inch of all the metatarsal bones near their heads should be excised, as section of the soft tissues alone will not be sufficient, while astragalectomy often will be beneficial as well. In many cases the condition is so painful and troublesome that the patient desires amputation, but this is to be avoided, as the condition nearly always can be corrected by the above methods ; and if proper fixation in plaster of Paris followed by the wearing of the type of boot above described is carefully carried out, the patients will be made comfortable.

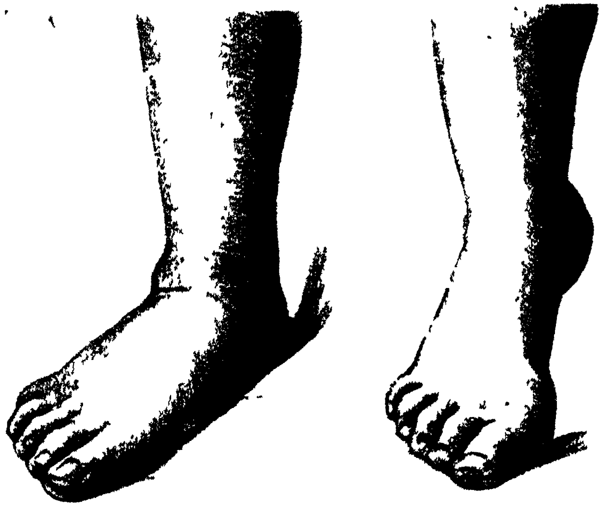


FIG. 360. Flat foot of the first degree, showing change when the patient rises on tiptoe.

Pes Planus (Flat Foot, Pes Valgus). This is a deformity in which there is loss of the longitudinal arch of the foot, while the foot becomes abducted and everted at the mid-tarsal joint, the latter element accounting for the name of pes valgus. It is very common, usually bilateral, and may occur by itself or in association with other deformities of the foot, while it may be due to several different causes (see p. 701).

Static or Adolescent Flat Foot. This is by far the commonest variety and is usually seen in young adults who carry heavy weights, have long hours of standing or walk about on hard pavements to which they are unaccustomed. It is more common in long and narrow feet, and is the result of the supporting power of the arch of the foot being insufficient for the body weight. Thus it is seen in rapidly growing children and feeble adolescents, when they commence occupations such as messenger boys or servants; the long periods of standing or weight carrying render them liable to the habit of standing in a position which throws the least possible strain upon the muscles, *i.e.*, with the feet apart and abducted, knees slightly flexed and the toes everted; a thoroughly bad position, for the result of this is that all the strain of weight-bearing is thrown upon the ligaments and bones of the feet, and this strain may be assisted by actual weakness of the tibialis posticus and anticus and by softness of the bones and possibly spasm of the peronei. In some cases this latter condition alone will cause the deformity. As the result of this the ligaments and soft tissues which support the longitudinal arch stretch, the inferior calcaneo-scaphoid ligament yielding especially, so that the head of the astragalus descends and the front portion of the foot becomes abducted, the scaphoid and os calcis being separated from each other by the descending astragaloid head.

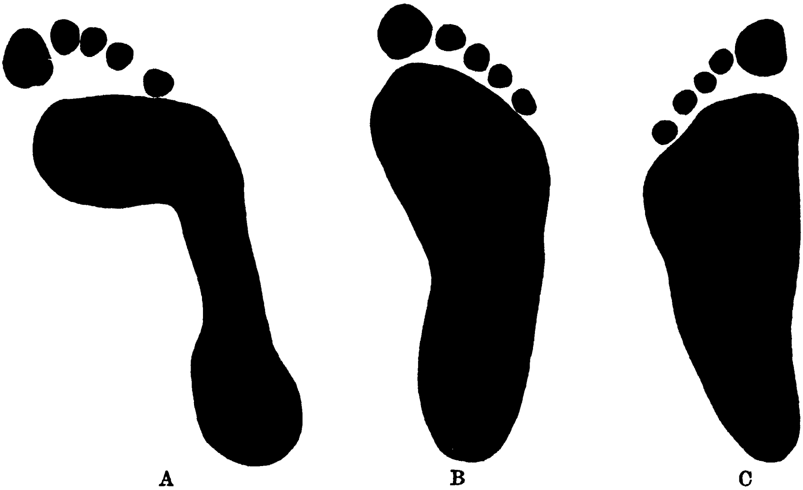


FIG. 361. Foot-prints. A, Normal. B, Moderate flat foot. C, Severe flat foot.

Clinically, therefore, it will be found that the sole of the foot is flat, coming in contact with the ground for almost the whole of its extent. The foot appears longer and broader than it should, and spreads out when the body weight is put upon it, its anterior half is everted and abducted, while its inner border may actually be convex. The tubercle of the scaphoid is less palpable than usual, while the sustentaculum tali may not be felt at all, but just below and in front of the internal malleolus a prominence will be felt due to the head of the astragalus. The internal malleolus is unusually prominent. The condition is often accompanied by a hallux rigidus or hallux flexus (see p. 704), while it will be found that the muscles of the legs are flabby and weak, and the movements of the feet are not free or easily performed by the patient. As the result of the increased length of the foot, the tendons may be too short, so that the toes may become contracted; the feet are usually found to be cold and covered with sweat, while the patient walks in a slouching and slip-shod fashion. If the foot-print is obtained (and this should always be done) it will be seen to differ greatly from that of the normal foot (see Fig. 361), while if worn boots are examined the instep will be seen to bulge towards the sole, which is worn away more on the inner side than on the outer side.

Subjective symptoms are present. At first the patient complains of slight pain and of getting very tired after walking and standing. This pain is usually more marked before the deformity has developed. In the early stages it is often most severe just behind and below the tuberosity of the scaphoid, where it is due to stretching of the spring ligament, but, in addition to this, it may radiate all over the foot and up into the calf. Stretching of the interosseous ligaments will cause pain across the instep, while in the later stages the external malleolus may press upon the os calcis and cause discomfort. Cramps in the muscles of the leg and foot at night are common, but when the arch has completely given way and the foot becomes absolutely flat pain may disappear altogether. When the condition has been present some time arthritis and other inflammatory conditions will occur in the little joints and give rise to adhesions, while these and also actual changes in the bones will render the deformity permanent.

It is usual to divide the cases clinically and from the point of view of treatment into four degrees :—

(*a*) *First Degree.* When the arch reappears and the deformity disappears if the patient takes his weight off the foot or rises on tiptoe.

(*b*) *Second Degree.* In which the deformity can be corrected by the surgeon's manipulations.

(*c*) *Third Degree.* Where the deformity can be corrected only under an anæsthetic.

(*d*) *Fourth Degree.* Where ankylosis and bony deformity have occurred, so that the deformity can be corrected only by means of operation.

Treatment. This condition can largely be prevented. In susceptible patients the muscles of the legs should be developed by exercises, while children should be taught to walk properly, with the toes pointing forwards and not outwards. Properly fitting boots should be used, and likely subjects should be taught to stand on tiptoe as much as possible. If much standing about has to be performed the optimum position is to stand deliberately upon the outer edge of the feet. Any arthritis, painful corns, etc., must receive proper treatment, as these may be causes of the condition. The principles of treatment consist in transforming the fourth degree into the third, the third into the second, and the second into the first.

(*a*) In the first degree there may be so much pain and disability that the condition is worthy of the name of *acute flat foot.* In this stage the patient must lie up completely for a few days while the legs and feet are massaged and Faradic baths are given and the general health is improved. This will enable the ligaments to recover their power and the muscles their tone. When the pain and tenderness have passed off, or in milder cases where they are less, he must be instructed in exercises and how to walk properly, while either standing or long walking must be avoided for the present. In standing he should rest occasionally on the outer edge of his feet and upon tiptoe, and in walking keep his feet parallel and rise well upon the balls of his toes.

There are certain exercises specially beneficial in the early stages.

(1) With his feet turned in, the toes touching and the heels separated, he should rise up and down on tiptoe.

(2) While standing with the feet parallel he should lift the inner borders of the feet off the ground and walk on the outer border of his feet.

(3) He should sit in a chair with one knee crossed over the other and rotate and circumduct the ankle to its fullest possible degree.

(4) In the same attitude as exercise (1), when up on tiptoe, he should bend the knees and squat on his heels, rising up again without the heels touching the ground.

These exercises should be carried out slowly for some minutes an increasing number of times day after day, but should not be permitted to cause pain or fatigue. In addition to this, massage, electrical treatment, and hot and cold douching should be employed. To relieve pain, all the patient's boots should be altered in such a way as to invert the foot so that it is thrown over on to its outer border. This is best done by means of square-toed boots, made with the inner borders straight, while the inner side of both the sole and the heel is raised about one-third of an inch by means of a wedge of leather. In addition to this, the heel should be low and must be carried forward on the inner side only, under the arch for about one inch. If spasm of the peronei muscles is a marked element in the condition, a tenotomy of these tendons may be a necessary preliminary. Faradic foot baths are both beneficial and comforting, and can be given alternate days. Massage and exercises must be avoided carefully in gonorrhœal and rheumatic cases until all pain and acute inflammation have passed off.

(*b*) In the second degree the treatment is roughly similar to that in the first degree, though here it is better that the support for the arch of the foot should be placed inside the boot and take the form of a metal plate, such as a Whitman's spring. In order to fit this satisfactorily, the metal spring must be moulded on a plaster cast taken while the foot is held in its proper position. If more support is needed, an outside iron to the knee with a valgus T-strap is fitted.

(*c*) In the third degree the deformity will have to be rectified forcibly under an anæsthetic and the arch restored. It is sometimes possible to do this with the hands, but more often a Thomas's wrench will have to be employed. In addition to correcting the deformity, it is wise to stretch and move the foot about in all directions to break down adhesions in the joints, and these will be felt to give way. The foot is then put up in its corrected position in plaster of Paris for six or eight weeks, after which properly fitting boots are provided and the treatment becomes that of degree (1). In some cases supplementary procedures before or after the above has been performed will consist in tenotomy of the peronei or transplantation of one of them into the tuberosity of the scaphoid.

(*d*) In the fourth degree the above procedure is impossible. Here in some cases the symptoms can be relieved by means of a carefully fitting instep pad. In other cases, however, elaborate operative procedures must be undertaken upon the bones: thus a wedge-shaped portion of bone should be removed from the inner side of the foot, including the astragalo-scaphoid joint, or in some cases the dislocated head of the astragalus should be excised. This will be followed by fixation in plaster and then exercises and massage.

Other Forms of Flat Foot. Many other forms of flat foot occur. A *spasmodic variety* is seen which is the result of painful spasm of the peroneal muscles. In many cases rest in bed will put this right, while in other cases it should be corrected under an anæsthetic and the foot put in plaster. Tenotomy of the peroneal tendons or crushing of the peroneal nerve have both been recommended for this condition.

A *paralytic form* occurs as the result of poliomyelitis. This is likely to be associated with one of the forms of talipes as well, and is accompanied by coldness and blueness, wasting of the limb and a flail-like ankle. The deformity is easily restored by manipulation, but recurs at once and should be treated either by tendon transplantation, tendon fixation or arthrodesis of the joints.

An *inflammatory form* of the disease is common. This is usually due to **gonorrhœa,** but may be due to septic inflammation, acute rheumatism, tuberculosis, etc. It is the result of inflammation and infiltration of the ligaments and plantar fascia, which cause them to yield rapidly, and is accompanied by swelling, redness, œdema and much pain. A similar change is sometimes seen associated with Charcot's disease or osteoarthritis. Rest is the first essential in the treatment of this variety.

A *traumatic form* is common and serious. This is due to severe injuries in the neighbourhood of the foot and ankle, and though sometimes due to fractures of the astragalus or of the os calcis or to rupture of the ligaments supporting the arch, it is much more commonly the result of a malunited Pott's fracture, in which the fibula has been allowed to become united with the foot in an everted and valgus position. The same condition is seen sometimes after badly treated fractures of the tibia and fibula, and must be guarded against most carefully. This form is very crippling and may necessitate an osteotomy of the fibula or tibia, or both, above the malleoli for its cure. The condition can be prevented in most cases of injury of or near the foot, if, when splints are discontinued, the patient wears a casing of Unna's paste, or varicosan bandage for the first three weeks or month that weight is borne on the limb. A similar condition may occur in patients who have been long in bed when they first get about on their feet, and when it occurs should be treated on similar lines with faradism to the leg muscles; it is best prevented by faradism or massage being given to the legs and feet while the patient is in bed.

A *rickety form* of the disease is sometimes seen, while in other cases it occurs as a *compensatory deformity*, secondary to some malposition of the limb above, such as coxa vara, genu valgum or curvature of the tibia.

A *congenital form* has been described of unknown origin, while it is said that a *racial* variety, with a strong tendency to run in families, is occasionally seen in Jews.

Painful Heels. It is not uncommon to find patients who suffer greatly from pain in the neighbourhood of the heel. Sometimes this pain is situated at the back of the heel, close to the insertion and lower part of the tendo Achillis, while in other instances it is situated under the heel where the foot comes in contact with the ground.

(*a*) In the first variety, when at the back of the heel, it is usually accompanied by tenderness round the tendo Achillis. It may be due to inflammation of this tendon, to inflammation of the bursa between this tendon and the posterior portion of the os calcis, to inflammation in an adventitious bursa formed over the tendo Achillis by the pressure of the boot or to subacute rheumatism. In some instances in children changes occur in the epiphyseal junction at the back of the os calcis, similar to those which occur in Schlatter's disease, and these may be the cause of the pain, while this portion of the skin is a favourite situation for chilblains to form. The treatment of this condition will depend upon the cause ; painful bursæ should be dissected out, while the other conditions are best treated by strapping and complete rest of the parts concerned. In some instances lowering high heels and wearing boots instead of shoes will be beneficial.

(*b*) When the pain is on the plantar surface of the os calcis it is frequently due to gouty deposits or inflammation of the muscles or fasciæ of the sole.

In some cases it is the result of a *spur of bone* growing down from the under surface of the os calcis, probably as the result of ossification in the deep fascia. This gives rise to considerable pain on pressure, standing or walking. The spur is usually bilateral, is easily seen in an X-ray film, and may have a bursa over it. At first it should be treated by pads and rings to keep the weight off it: if this fails it should be removed by operation, a horse-shoe flap being turned forwards so that the incision is not on the sole of the foot. The results of this operation are often disappointing.

In other cases pain in the substance of the os calcis is the result of a fall which has given rise to a crack or fracture of the bone. This may persist for a very long time and is very intractable (see p. 524).

Hallux Valgus. This is a deformity of the great toe in which the toe turns outwards at the metatarsophalangeal joint, away from the other foot, and lies above or below the second toe, causing the other toes to be huddled together. It is a very common deformity, is especially seen in women, is often bilateral and associated with pes planus. Though it is sometimes seen in the bare-footed pigmy races in Africa, there is little doubt that it is largely caused by the wearing of tight stockings and boots which are short and pointed and high heeled. The boot presses the toe over to the outer side, and the presence of a high heel increases the deformity, as it forces the toes further down into the boot. In other instances the condition is due to a chronic osteoarthritis, permitting the stronger adductor group of muscles to draw the toes over. The condition develops slowly and, as the toe bends over, the inner side of the articular portion of the head of the first metatarsal bone becomes uncovered and projects on the inner border of the foot, while the first phalanx becomes displaced on to the lateral aspect of its head. As the result of the pressure of the boot upon this exposed portion of the head, fibrillation and wearing away of the cartilage occurs, new bone is laid down and the head becomes greatly swollen and enlarged. All the changes characteristic of osteoarthritis sooner or later appear in the joint if not present at the beginning, and the toe becomes fixed in its displaced position. The foot becomes broadened, and the distal portion of the great toe may be rotated so that its plantar surface looks outwards.

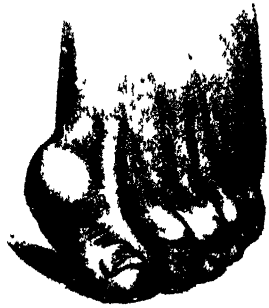


FIG. 362. Hallux valgus with a large bunion.

Another result of the pressure of the boot upon the prominent metatarsal head is to produce a great thickening of the skin with an adventitious bursa beneath it, this condition being known as a **bunion.** The bursa becomes greatly thickened and frequently becomes inflamed and suppurates, forming abscesses and sinuses. This bursa sometimes communicates with the joint, and its inflammation gives rise to considerable periostitis and further formation of new bone. The patient's chief complaints are of pain, due to the inflamed condition of the joint and the bursa over it, and the alteration of the shape of the boot. The condition is frequently accompanied by a considerable degree of hallux rigidus or flexus (see p. 704), to which it may be secondary. It is held by some authorities that this condition is liable to develop after amputation of the second toe. The patient's boots become bulged outward over the joint, and this may be very noticeable.

Treatment. This will depend upon the stage of the condition. In the early stages the wearing of properly shaped boots, stockings with a separate compartment for the great toe, or a toe post consisting of rubber or cotton wool between the first and second toes, together with manipulation and exercises, will help greatly. When inflammation and sepsis in the bursa are prominent these must be got rid of by rest and appropriate treatment. Any causative condition present must be corrected, while at night the toe may be strapped into its proper position by a splint

In the more severe cases operation will be required. In this connection it must be remembered that the chief pain and disability are due to the prominent enlarged head of the metatarsal which projects inwards and the inflamed bunion upon the top of it. It should be remembered also that women especially will not be particularly grateful for any operation which aims at widening the foot, as would be the case if the big toe were brought back towards the middle line. In most cases, therefore, there is no need to interfere with the joint more than can be helped and no need to remove the whole of the head of the metatarsal bone. It is sufficient to turn up a flap on the inner side of the foot, to dissect out the bunion, carefully retract the extensor tendon outwards, and saw or chisel away all the prominent portion of the metatarsal head which projects inwards until the side of the head lies perfectly flush with the rest of the shaft. In less serious cases still, excision of the thickened bursa alone will be sufficient.

In the more serious cases, especially those where hallux rigidus is present also (see below) so that the movements of the big toe are greatly interfered with, it will be necessary to do something to mobilise the toe, and the removal of the whole metatarsal head will be necessary. A similar flap is turned up, the tendon retracted outwards, and the joint opened. The neck of the bone is divided by a chisel or saw obliquely, so that the cut surface faces forwards and slightly upwards and inwards. A flap of soft tissues is then cut and turned inwards in front of this raw surface to help in the formation of a new joint and the skin sutured. The toe is then fixed almost straight and dorsiflexed to an angle of about 30 degrees, with strapping and massage and movements commenced as soon as the wound is healed soundly. This is a considerably more severe operation than the last, and one which is followed by much pain. Proper boots should be worn afterwards in some cases, while a bar placed across the sole just behind the balls of the toes will be helpful, and often a transom arch support may be necessary.

Hallux Varus (Pigeon Toe). This is a rare deformity occasionally seen in children in which the big toe is displaced inwards. It is, therefore, the reverse of the foregoing condition, and is usually associated with other deformities. The toe should be straightened by dividing the tendons and ligaments as far as is necessary and held in that position by strapping and plaster of Paris.

Hallux Rigidus and Hallux Flexus. These are two different stages of the same deformity. They are due to a chronic osteoarthritis of the metatarsophalangeal joint of the big toe, which is usually seen in young men with long, thin, flat feet; the condition is usually bilateral and frequently associated with a spastic flat foot.

In *hallux rigidus* the toe is quite stiff and dorsiflexion is impossible, while the joint is swollen, painful and tender. The toe itself is usually in good position.

In the later stage, ***hallux flexus***, as well as being fixed and immobile, the toe becomes plantar-flexed permanently, while the terminal phalanx may become hyperextended. A certain number of cases give a definitely traumatic history, while in others it is a sign of commencing flat foot. Walking is painful, and the patient finds it difficult, as owing to the stiffness of this joint he cannot rise upon his toes and has to turn the foot over sideways, while the boot becomes worn away at the inner side of the point of the toe and the inner side of the back of the heel. All the changes characteristic of osteoarthritis will be found in the joint, the flexion of the toe being due to contraction of the ligaments, while the exposed portion of the articular surface of the dorsum of the metatarsal head becomes converted into fibrous tissue and the bone may be greatly thickened and overgrown.

Treatment. In the early stages this consists largely in the treatment of associated flat foot by the wearing of suitable boots or arch supports, while if any signs of acute arthritis are present rest will be necessary until the pain has passed off; a metatarsal bar will make the patient walk much more comfortably. In the more advanced cases, where the toe is fixed or where hallus flexus is present, further treatment will be required in order to bring the toe into a dorsiflexed position, as otherwise walking becomes very difficult. In some cases the fault can be put right by wrenching the toe and forcing it up into a dorsiflexed position under an anæsthetic, fixing it there with strapping or plaster. More often, however, this cannot be done, and then open operation will be necessary. This is performed on the same lines as the operation for severe hallux valgus, and it is always necessary to remove the head of the metatarsal, cutting the bone obliquely downwards and forwards so that the toe can be put up in dorsiflexion. If all else fails, the sole of the boot must be made absolutely rigid with a metal plate so that dorsiflexion cannot occur when the patient walks; this will relieve the pain.

Hammer Toe. This is a very common deformity which usually affects the second toe, but is by no means confined to it; several toes are often affected simultaneously. Occasionally congenital, it most often appears about the age of puberty, while it may be secondary either to pes planus or hallux valgus. There is no doubt that the wearing of improper boots which are short or pointed, or with high heels, plays a considerable part in the production of the deformity, while in some instances there is a distinct family inheritance.

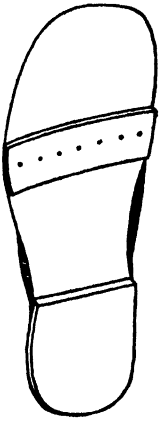


FIG. 363. A metatarsal bar.

The first phalanx is dorsi-flexed, the second plantar-flexed, while the third may be dorsi- or plantar-flexed. Thus the first interphalangeal joint projects up above all the other toes, while the digits on either side of the toe affected tend to overlap its tip. Painful corns or callosities form upon the pressure points, while a painful bursa frequently forms over the head of the first phalanx, this bursa frequently becoming inflamed. The pulpy tissues at the tip of the toe become flattened out by the pressure of the toes on either side of it. It is usually found that the contractures are due chiefly to contraction of the lateral prolongations of the plantar fascia and the lower portion of the lateral ligaments of the joints. There is as a rule no shortening of the tendons.

Treatment. Many cases require no treatment, while in the early cases the wearing of proper boots, manipulations, and strapping the toe down to a short splint at night may be sufficient; but in more severe cases tenotomies will be necessary. Before these are undertaken any sepsis or inflammation must be treated. Operations devised to cut the contracted ligaments are very rarely successful, and by far the best procedure in severe cases is to remove the first phalanx completely. This is best done by a longitudinal dorsal incision splitting the extensor tendon; the toe is then fixed completely down on to a short splint for a few days.

An alternative treatment is amputation of the toe, but this should not be performed in candidates for the public services, as they may not be accepted after amputation of a toe. This should be done if there is very little room between the first and the third toes for the straightened second toe to lie in. In the case of the second toe, it is sometimes said that hallux valgus is liable to follow this procedure, but this is very doubtful.

Metatarsalgia (Morton's Disease). This condition consists of severe neuralgic pain, which commences in the head of one of the metatarsal bones, usually the fourth, and radiates from there right across the anterior arch of the foot, and also up the leg. In some instances it follows an injury; it may be associated with gout or rheumatism, is most common in women over thirty, and is undoubtedly predisposed to by flat foot and tight boots. The anterior transverse arch is found to be flattened out, and the front part of the sole of the foot is broadened. Corns or callosities are found under the metatarsal heads, while sometimes bony outgrowths will be found upon the under surface of these bones. The pain is thought to be due to stretching of or pressure on the digital nerves between the metatarsal heads and the ground. The condition comes on insidiously, while when well marked severe pain is induced by walking; this may be a dull ache or consist of sharp, intense, cramp-like spasms, of very sudden onset. Rest, taking off the boot, and pressure upon the metatarsal bases relieve it, while pressing the heads of the metatarsals together or pressing upon the sole of the foot beneath them increases it. In severe cases the patient is crippled and unable to walk without a crutch. An X-ray photograph will show a downward displacement of one or other of the metatarsal bones, while usually there is evidence of osteoarthritis in the small joints around.

Treatment. In the mild cases treatment of the flat foot and rest, massage and faradic baths, with suitable drugs and diet to overcome rheumatism, will be sufficient. When the patient commences to walk again a tight bandage or pad under the instep will be useful. She should have specially fitted boots which have low heels, are broad in front and narrow round the instep, not pointed, with the inner edge of the sole and heel slightly raised and a metatarsal bar across the sole (see Fig. 363). An arch support to the transverse arch is often helpful. In more severe cases, and when displacement of one of the metatarsal heads can be seen and felt, the head of the bone (usually the fourth) should be removed by a longitudinal dorsal incision, as this will relieve pressure upon the nerves.

Other Deformities of the Toes. There are other rare deformities of the toes. *Polydactylism,* in which extra toes are present, which may be developed fully or only partially, is seldom seen; if causing symptoms or interfering with the boots, they should be removed.

Syndactylism, or *webbing of the toes,* is less common than a similar condition of the fingers. Two or more toes may be involved; they may be united only by a thin web of skin or more extensively fused to any degree. In some instances the metatarsal bones are fused, in others the phalanges as well, the toes merely appearing as one broad digit having two nails. Unless they are much overgrown and causing trouble they require no treatment (see p. 712).

Contracted Little Toe. The little toe is often contracted and drawn over the toe next to it; when this occurs, it is often the seat of very painful corns. There need be no hesitation in amputating the toe.

Hypertrophy of the Toes. One or more of the toes is occasionally found to be hypertrophied. This is a congenital condition which may involve all the tissues of which the toe is composed or only affect the subcutaneous tissues. If necessary the whole or only part of the toe or toes affected should be amputated.

DEFORMITIES OF THE UPPER LIMB

Congenital Absence of Bones. One or both *clavicles* are occasionally absent, or one or other bone may have its outer half completely absent, and when this is so the patient can usually make his shoulders meet in front of his chest; the condition is usually accompanied by a general deficiency of the bones developed in membrane (Chapter XVIII., p. 529). Remembering that in the horse the clavicle is never present, it is not surprising that this condition causes practically no disability.

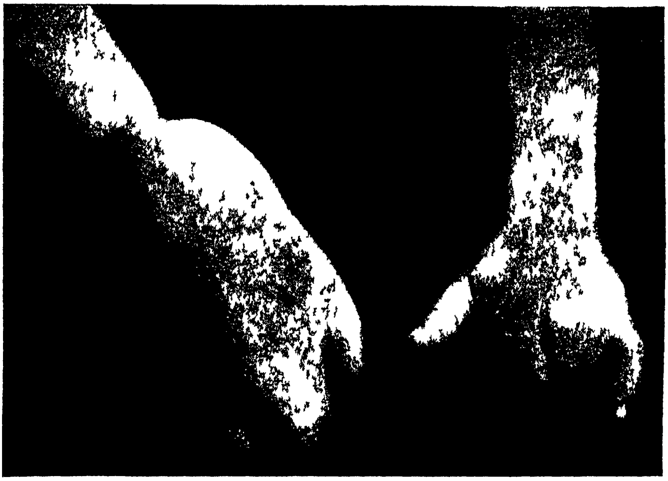


FIG. 364 Deformity of the hands with absence of several bones.

The *radius* is not infrequently absent, either completely or partially. When this occurs a club hand is associated with it, the forearm being shortened and the hand markedly abducted to the radial side. It is usually found that the ulna is shortened and bent, while frequently the thumb and its metacarpal bone are absent also.

The lower epiphysis of the ulna is usually expanded to articulate with the carpal bones. This condition sometimes may be improved by splitting the lower end of the ulna longitudinally and forcing the first row of bones into the cleft to form a new joint.

Absence of the ulna is very rare.

Absence of one or more fingers sometimes occurs, while intrauterine amputation of the whole or part of the limb is occasionally seen. When fingers are absent the condition is sometimes accompanied by maldevelopment of the ulna or radius. Sometimes the fingers are represented only by short, rounded stumps.

Congenital Dislocations. *Congenital dislocation of the shoulder* is sometimes seen. It is often bilateral and accompanied by other deformities. It is usually found that the glenoid cavity is maldeveloped and the movement and development of the whole arm are restricted. The dislocation may take up any of the standard positions (see p. 455), and sometimes can be reduced by manipulation or operation.

Another form of dislocation may occur in early life and be the result of poliomyelitis or injury to the brachial plexus, especially when affecting the fifth cervical nerve. In this case the lack of muscle tone allows the arm to drop and the capsular ligament to be stretched. Marked wasting is noticeable round the shoulder, the acromion and scapular spine are prominent, and several fingers may be inserted into a marked depression present between the acromion and humeral head, while the arm hangs flaccid in the position of an Erb's palsy (see p. 357) and the shoulder cannot be moved. This condition will be treated best by transplantation of muscles and tendons ; the operation must be devised according to which muscles are paralysed and which are active (see pp. 716 to 718). If this fails an apparatus may be fitted to steady the arm, or the shoulder joint may be ankylosed in a position of abduction.

At the elbow congenital dislocations are rarely seen. Both ulna and radius are practically never dislocated, but dislocation forwards or backwards of the *radial head* will sometimes be encountered, and is usually the result of imperfect development of this bone and the humeral condyle. If causing symptoms the radial head should be excised.

Congenital dislocation of the wrist is very rare ; but minor degrees of congenital dislocation of the fingers are common ; they are usually very slight and lead to no disability. The terminal phalanges of one or more fingers or thumbs sometimes exhibit a slight lateral deviation which is rather unsightly but causes no disability ; there is no treatment for it.

Congenital Elevation of the Scapula (Sprengel's Shoulder). This is a rare deformity affecting the upper part of the spine and the shoulder and not usually noticed until the child is several years old. Then it will be seen that the scapula is placed higher than normal while its lower angle is rotated towards the midline, giving the patient the appearance of lifting up one shoulder. The bone itself is sometimes smaller than usual, and does not move as freely as it should, while a small amount of scoliosis and underdevelopment of the affected arm is sometimes seen. Most commonly the muscles passing from the upper border of the scapula are prominent and taut and appear to be holding it in its abnormal position, but in other instances a bridge of bone, cartilage or firm fibrous tissues will be found running from the superior angle of the scapula to the sixth or seventh cervical vertebra. There even may be a false joint at one end of this bony bridge, while other abnormalities in the ribs and spine may be present ; thus the ribs may be flattened, the spinous processes of some of the upper dorsal vertebræ may bend towards the affected side, the vertebral bodies may be asymmetric, some of the ribs be bifurcated and the serratus magnus and part of the trapezius may be absent. Rarely the condition is bilateral, when the neck appears short and thick and the chin is close to the sternum. In this condition the arm feels weak and there is difficulty in elevating it up to or above the shoulder.

Treatment. Massage and exercises may be helpful in mild cases, but in most cases operation will be necessary to free the scapula. An X-ray photograph will be necessary to see if bony bars are present, and if present such a bony block must be excised. In other cases the muscles and fibrous tissues attached to the upper angle of the scapula must be divided and lengthened, so that the bone can be drawn down and fixed in its proper position.

Winged Scapula. This backward displacement of the scapula is due to paralysis of the serratus anticus (magnus) and rhomboid muscles (see p. 359). The treatment is there described. If general treatment and massage fail to produce a cure, a padded corset will be found useful, while occasionally stitching the latissimus dorsi on to the lower angle of the scapula may diminish the deformity. In other cases a portion of the pectoralis major may be detached from the humerus and stitched into the serratus muscle or even into the axillary border of the scapula.

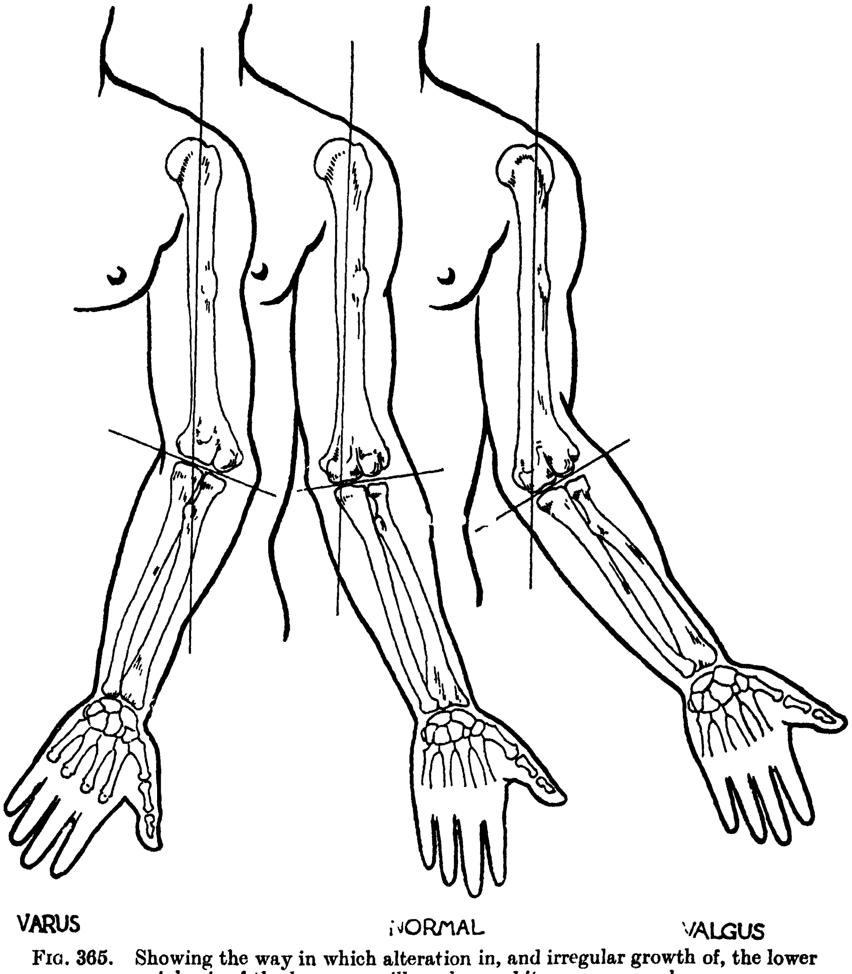


FIG. 365. Showing the way in which alteration in, and irregular growth of, the lower epiphysis of the humerus will produce cubitus varus or valgus.

A paralysis of the trapezius muscle sometimes causes an upward and outward displacement of the scapula. This deformity gradually disappears as the muscle recovers or other muscles take over its function.

Paralysis of the latissimus dorsi muscle leads to the lower scapular angle being unduly prominent.

Congenital dislocation of the head of the radius is a rare deformity. It is unilateral and the head of the bone is displaced anteriorly. Removal of the head of the radius is usually required (see p. 708).

Paralytic Deformities. A large group of paralytic deformities occur in the arm in different situations. Those round the shoulder are described on p. 354.

As the result of poliomyelitis the muscles round the elbow joint may be paralysed, rendering that joint flail-like and useless, while the hand may be unaffected and still useful. In this case a permanent fixation or ankylosis of the elbow joint by means of arthrodesis will be of great service. The joint should be fixed in a position of semi-pronation at slightly less than a right angle.

At the wrist the condition of wrist-drop is a common result of poliomyelitis and lesions of the musculo-spiral nerve, traumatic or toxic, and due to such conditions as lead, alcohol or arsenic neuritis. The treatment of these conditions is described on p. 362.

A similar condition is sometimes the result of spastic paralysis. Here the elbow and wrist are flexed and usually pronated and fixed in this position. Gradual extension and stretching of the muscles can usually be achieved by a malleable splint whose angle is continually altered. In more severe cases tendon lengthening or transplantation will be required.

Cubitus Valgus and Varus. In the normal limb the forearm and upper arm meet at an angle which opens outwards and is known as the carrying angle, and this is more marked in women than in men. In men it is usually about 170 degrees (Fig. 365). As the result of various conditions this angle at which the bones meet may be altered. When this angle is decreased so that the hand deviates further from the midline of the body than it should, the condition is known as *cubitus valgus*, while the reverse condition is called *cubitus varus*, and is more common. These deformities arise as the result of rickets or from fractures of the lower end of the humerus, separation of the epiphysis of the lower end followed by interference with the growth of the bone and fractures of either the internal or external condyle of the humerus. Although looking ugly, they do not, as a rule, give rise to much disability. If severe they may be corrected by a supra-condylar osteotomy of the humerus. Cubitus valgus is occasionally associated with pressure on or neuritis of the ulnar nerve, and this may require treatment.

Volkmann's Ischæmic Contracture. This is a contraction and fibrosis of the muscles of the forearm and is described on p. 410.

Ankylosis of the Radio-Ulnar Joint. Congenital fixity of the superior joint between these two bones is a rare condition, but one which is occasionally seen. Supination and pronation are absent, while flexion and extension of the elbow are free. The best treatment is excision of the head of the radius.

Congenital Club Hand. One variety of this condition has been described on p. 707, where it is due to the absence of either the radius or the ulna. A similar condition in which the hand deviates to one or other side (*manus valgus or varus*) occurs as the result of diminished growth of one or other bone from epiphyseal injury or disease. In this case the longer bone should be shortened by osteotomy.

More rarely other forms of congenital club hand occur where the hand and fingers are tightly flexed towards the ulnar or radial side, probably as the result of faulty position in utero. The treatment is the same in principle as that for talipes (see p. 700). A marked degree of this condition, though not, of course, congenital, is sometimes seen as the result of rheumatoid arthritis.

Another somewhat rare deformity of the wrist (**Madelung's deformity**) was described by Madelung as a subluxation, but there is little doubt that it is due to deficient growth at the lower radial epiphysis as the result of injury. The condition may be either bilateral or unilateral, and the radius becomes concave forward while the ulna continues to grow, so that its lower end projects on the back of the wrist. The whole carpus and hand are pushed over towards the radial side and also towards the palm, but they are not twisted laterally or abducted. The condition is usually seen in young women without any definite history of injury, but whose hands and wrists are subjected to long-continued strain. Dorsiflexion is limited, and all movements of the hand and fingers, especially the grasp, are weak. Massage and exercises should be given, while the wrist should be supported by a moulded leather support extending from the forearm to the knuckles. This should be moulded with the hand in a corrected position as far as possible.

DEFORMITIES OF THE FINGERS

These are common and exist in many different varieties. Very similar deformities are found in the toes, but they are much less common.

Congenital Contraction of the Fingers. This is by no means uncommon and is inherited, being seen in several members of the same family. It is most common in girls and is usually limited to the fourth and fifth fingers, frequently being bilateral. The characteristic deformity consists in dorsiflexion of the first phalanx and palmar flexion of the second and third phalanges. This is exactly the reverse deformity to that which occurs in acquired contraction of the fingers (Dupuytren's Contracture, see below). It is thought to be due to contraction of the central portion of the palmar fascia of the finger, though some authorities regard it as the result of absence of the anterior ligament of the joint. The palmar portion of the fascia is not affected, while the characteristic hardening and thickening of the fibrous tissues seen in Dupuytren's contracture are not present here.

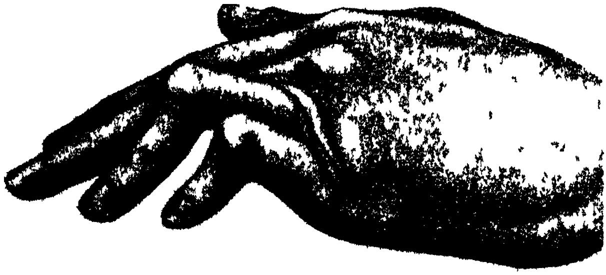


FIG. 366. Congenital contraction of the fingers.

Treatment. The condition is not usually noticed, at any rate not treated until the child is seven or eight years old. In most cases massage and exercises and the wearing of a splint at night will be sufficient, as the disability is very slight, but in more severe cases division of the contracted bands of fascia may be necessary. In some cases a cuneiform osteotomy of the dorsal aspect of the first phalanx will be required.

Dupuytren's Contracture (Acquired Contracture). This is an acquired contracture met with in middle-aged people and most common in men, in whom it may be bilateral or unilateral; a few instances have occurred in young adolescents. It is due to contraction of the palmar portion and the lateral digital prolongations of the palmar fascia, combined with a considerable amount of overgrowth of the tissues. In some instances it is hereditary, while there is no doubt that a gouty or rheumatic tendency plays a part in it; many other causes have been assigned to it, such as syphilis and local septic infections, but there is no evidence of these. It is very common in the hands of working men, where it is possible that it is the result of irritation by the pressure of tools and instruments upon the palm of the hand, though the fact that it is so frequently bilateral makes this very unlikely. Usually the fourth and third fingers are chiefly affected. The condition commences as a small subcutaneous, indurated mass in the inner and distal portion of the palm of the hand, usually opposite the ring finger, and quite painless. The skin over this is puckered and adherent. After a time the metacarpo-phalangeal joint flexes, while the induration spreads up this finger and on to the next ones. Next the second phalanx flexes, while the fourth and second fingers will commence to bend too. The index and thumb are very rarely affected. In severe cases the fingers are gradually drawn into the palm and held there rigidly flexed and motionless. The terminal phalanx does not flex as the fascia does not run as far as this, and in some cases from the way in which it is pressed against the palm of the hand the terminal phalanx will become hyperextended. The fat under the skin disappears, so that the skin and fascia become adherent and the skin greatly thickened and puckered. The tendons, tendon sheaths, bones and joints are not involved. The condition is painless, but the use of the hand is greatly interfered with. Inasmuch as the first two phalanges are acutely flexed and the terminal one hyperextended, it will be seen that the deformity is exactly opposite to that of congenital contracture (see p. 711).

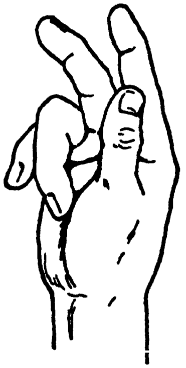


FIG. 367. Dupuytren's Contracture.

It must not be forgotten that there are several other causes of contracted fingers. Volkmann's contracture, scarring as the result of burns and other injuries, scar tissue formed from severe septic fingers, especially those which have involved the tendon sheaths, cut or adherent tendons, ankylosis of the interphalangeal joints, rheumatoid arthritis and gout, and the results of injuries of the ulnar or median nerves are all causes. A careful examination and history always will make the cause clear.

Treatment. In the early stages passive movements, fibrolysin injections, massage and exercises, together with the wearing of a splint at night to prevent the fingers flexing, will relieve the condition. Fibrolysin is a solution made up as follows: Thiosinamin parts 10, glycerine parts 20, water parts 70; one-half to three c.c. is injected into the scarred tissues or an ointment may be rubbed in. When, however, severe flexion has already occurred, the condition must either be left untreated or operated upon, according to circumstances, as no other treatment then is of any avail. Several operations have been devised; Adams' operation is a subcutaneous division of the fascia and indurated bands by puncture and division with the tenotome at several places where bands can be felt to be hard and contracted, the finger being kept on the stretch all the while. The skin also may be separated from the fascia by this means. The finger is then forcibly stretched open, and should the skin tear and give way at any point it must be grafted. Careful splintage to keep the finger extended, especially at night, and massage and movements must be persisted in, but as there is a considerable tendency for the contraction to recur, the results are not very satisfactory, Another operation ascribed to Kocher consists in turning back flaps of the skin and completely dissecting away all the fascia and thickened bands in the palm and finger. When the finger is straightened there probably will be a gap in the skin which will need grafting. If there is difficulty even then in straightening the finger the head of the metacarpal bone may be excised and the extensor tendon shortened. Careful splintage to keep the finger straight for a prolonged period, with early massage and movements, will be required again: a splint must be worn at night for at least one year and better for life. Some cases are so severe and produce so much flexion of the little finger that this digit may need amputation. Should skin grafting be required in this condition, it should consist of thick grafts with subcutaneous fat, and this is best performed by placing the bare portion of the finger under a flap of skin on the abdominal wall and fixing it thus with plaster of Paris for ten days before setting the flap free at its ends.

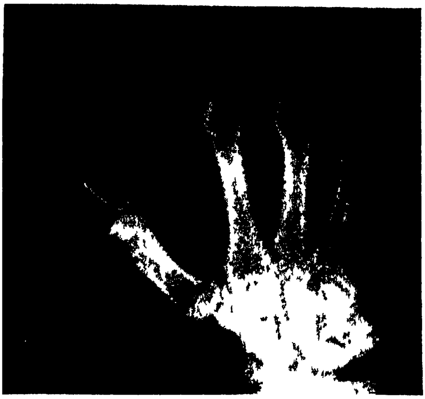


FIG. 368. Polydactyly, showing double thumb.

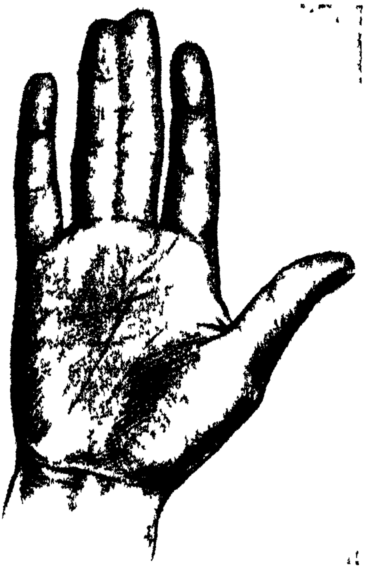


FIG. 369. Syndactyly.

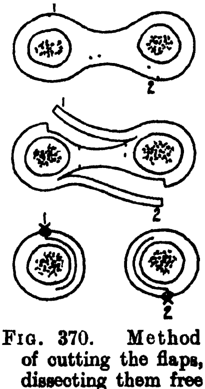


FIG. 370. Method of cutting the flaps, dissecting them free and suturing them in syndactyly. (Didot's operation).

Polydactylism. This consists in the presence of supernumerary fingers; there is often also an excess of toes. The condition is rare and tends to run in families. Any number of extra digits from one to six have been recorded. The condition is usually symmetrical, while the accessory digits vary enormously, sometimes being fully formed and of full size, while in other cases they are stunted and may consist of only a tag of skin or piece of cartilage. Usually they are separate and distinct, or they may be fused with the other digits, while there may be an increase in the number of metacarpal bones or only the ordinary five. The most extensive case on record had in all thirty-seven toes and fingers. As the supernumerary digits nearly always get in the way and look ugly, they are usually best removed, though it is best not to do this until the age of five or six; these fingers seldom have much power of movement.

Syndactyly (Webbed Fingers). In this condition two or more fingers are congenitally joined together at their sides. The condition also tends to run in families and may be accompanied by polydactyly or congenital hypertrophy. The bond of union may be only a thin web consisting almost entirely of skin, a thick fleshy mass of tissue, or there may be complete fusion of the fingers with only one set of bones. The condition is ugly and gives rise to disability.

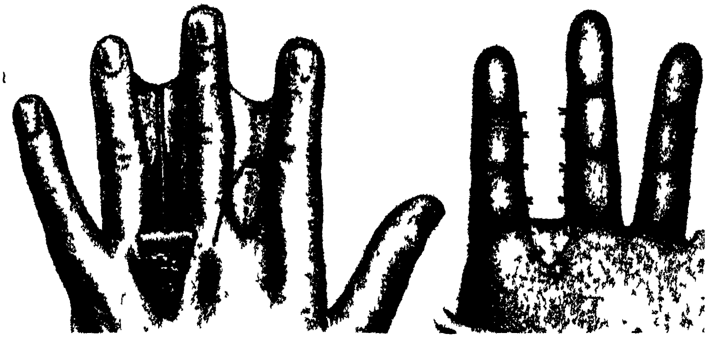


FIG. 371. Agnew's operation for webbed fingers The flap is dorsal, large and single (Keen and White "American Textbook of Surgery.")

Treatment. There is no treatment except operation, and this is better not performed till after the age of six years. If only a thin web is present it may be divided and the edges sutured on either side. The greatest care must be taken not to leave a raw space at the angle between the fingers, or as healing occurs the web will re-form. To prevent this a small skin graft or triangular skin flap must be placed over this area, or the lower part of the web dealt with first and allowed to heal before the upper part is cut. Where a thick and fleshy bond of union is present, flaps of skin will have to be cut, as in Fig. 370, and be wrapped round the fingers on their raw surfaces. The angle between the fingers must again be carefully covered.

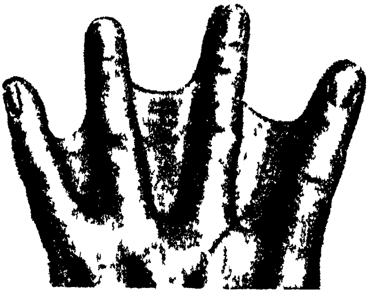


FIG. 372. Norton's operation for webbed fingers. The flaps are small and double.

A simple method which sometimes succeeds is to pierce the base of the web where the cleft should begin, and to wear a piece of wire or fine drainage tubing through the hole until it is healed. Once this is healed (about 3 or 4 weeks) the rest of the web may be slit up and sutured. The accompanying Figs. 371 and 372 will explain the principles of Agnew's and Norton's operations.

It must not be forgotten that these operations may cause marked loss of blood, or severe sepsis and sloughing.

An acquired condition of syndactyly is occasionally seen as the result of burns, wounds and ulceration involving the sides of the fingers. This, however, should be preventable by early skin grafting. When it occurs its treatment is the same as in the above condition.

Macrodactyly (Congenital Hypertrophy of the Digits) is a rare condition affecting one finger or thumb. It is a form of local gigantism, all the tissues being affected and the finger being properly formed but two or three times its proper size. It continues to grow in size. The only treatment is operation; in most cases this will consist in amputation, though in a few instances it may be possible to trim the finger down.

Acquired Contractures of the Hand. Many different varieties of acquired contractures are seen in the hand as the result of burns, wounds and other injuries, sepsis and lupus. They are seen also as the result of injuries to the tendons and lesions of the ulnar and median nerves. Many of these conditions are so severe that treatment is hopeless.

Trigger Finger (Snap or Spring Finger). This is an acquired condition in which a finger or thumb, after the fist has been clenched, refuses to open with the other digits and remains flexed, requiring the assistance of the other hand to pull it open, when it flies back into extension with a slightly painful jerk or click, like a clasp knife or gun trigger. In some instances the finger is also rather difficult to flex, and there may be tenderness over the line of the tendon. In most cases the condition is due to a swelling of the tendon, which prevents its moving freely within its sheath. It is occasionally caused in the thumb or index finger by a sesamoid bone or a ganglion, while the condition is undoubtedly associated with a rheumatic tendency. Many cases recover under massage and anti-rheumatic treatment. If this fails, the tendon is exposed and the thickened part pared down to its proper size and the sheath left unsutured.

Mallet Finger (Drop Finger). See p. 482.

OPERATIONS ON THE LIMBS

Operations on Bones. The operations for fixing bones together after fractures are described in Chapter XIV. These various methods of fixation, such as plates, grafts, pegs, screws, wires, etc., may also be of use after portions of bones have been removed surgically.

Osteotomy. This operation consists in cutting across a bone and is performed to correct some deformity which may be due either to an altered shape of the bone itself or to disease and ankylosis of a neighbouring joint. In some cases a similar result may be achieved by breaking the bone without cutting it; this latter operation, known as **osteoclasis**, can be performed in children with the hands, or in older patients by means of an instrument known as an osteoclast. It, however, presents no advantage over osteotomy and considerable disadvantages, and should never be performed. Osteotomy may be of two kinds:—

(*a*) Cuneiform.
(*b*) Linear.

(*a*) *Cuneiform Osteotomy.* This is an operation not often performed. In addition to cutting the bone across, a wedge-shaped portion is cut out of it at the line of section. It will be seen, therefore, that it is only applicable where the deformity is so great that mere section of the bone will not be sufficient to correct it. The only situation where it is likely to be required is either at the knee joint when ankylosis and marked flexion are present, or in the tarsus for severe talipes. Occasionally it is required at the upper end of the femur for ankylosis of the hip or severe coxa vara. In this operation the bone must be exposed freely by a large incision and the wedge chiselled or sawn away. After this it is advantageous to fix the bone by one or other of the methods described on p. 432, together with external splintage such as plaster of Paris.

(*b*) *Linear Osteotomy.* Here the bone is simply divided across and fixed in good position, no portion of it being removed. This is usually done with an osteotome or a small and narrow saw. An osteotome resembles a chisel, with the exception that both sides of it are bevelled and there is usually a scale in inches marked along one border. The operation is usually done in the form of a subcutaneous operation through a small incision in the skin, about half an inch long and just sufficient to admit the osteotome or saw, the best saw to use being the narrow Adams' saw. Through this small incision the knife is passed down to the bone, and down the narrow track thus made the osteotome or saw is introduced. The incision is usually made along the axis of the limb, the osteotome introduced in this direction and then rotated through 90 degrees, so that its axis lies across the bone, the limb being placed on a sandbag. When the osteotome is in contact with the bone it is driven in with mallet blows. In addition to being driven transversely across the bone it should also at times be given a slight upward and downward direction, but once the section of the bone is commenced the osteotome, if possible, should not be removed from the groove already cut, or it may be difficult to replace it therein. Only about three-quarters of the bone should be thus cut through, the final portion being broken by bending the limb. One stitch is put in the incision, and the limb is then put on a splint in its corrected position. This is best done by means of plaster of Paris, a small window being left through which the stitch can be removed.

Certain special osteotomies have been described.

(1) **Macewen's Osteotomy.** This is usually performed for severe genu valgum, genu varum or ankylosis of the knee, and consists in division of the femur about half an inch above the upper border of its internal condyle. It is done as described above by a half-inch incision either on the inner or outer side of the thigh, the former being Macewen's original operation, but the latter being in most cases the better; a saw may be used here if preferred. Care must be taken in cutting the back portion of the femur not to damage the popliteal artery or vein. Macewen's original incision lies half an inch in front of the adductor tubercle and half an inch above the internal condyle so as to avoid damaging the epiphyseal line. A surprising amount of chiselling will have to be performed in this operation before the bone can be broken, and this should be directed chiefly against the hard bone round the periphery. The limb must be fixed firmly after the operation in its corrected position in plaster of Paris for about six weeks.

(2) **Gant's Subtrochanteric Osteotomy.** This osteotomy consists in cutting the femur immediately below the greater trochanter. It is performed with an osteotome through a half-inch incision as already described and is usually required for ankylosis of the hip joint in faulty position or severe cases of coxa vara. The limb should be fixed in plaster of Paris after the operation for about two months. Before correcting the position of the leg in severe cases it may be necessary to cut the adductor tendons or other soft tissues.

(3) **Adams' Osteotomy.** This is an old operation devised to sever the neck of the femur, but it is rarely performed now. The conditions in which it has been used are faulty ankylosis of the hip joint and severe coxa vara, but in both these conditions the neck of the bone has almost ceased to exist, and in old tuberculous cases the section will be made too near the diseased area. It was for this operation that the Adams' saw was originally devised.

(4) Osteotomy of other bones, usually accompanied by resection of a portion of a limb bone, is sometimes required with a view to increasing the effective length of tendons, as in Volkmann's ischæmic contracture, or to permitting the suture of nerves whose ends cannot otherwise be brought together. It is also required at the site of malunited fractures with a view to enabling them to be placed in proper position; in all this last group of operations an open operation with a large incision will be required.

Operations on Tendons. The tendons of the body are divided into two main classes:—

(*a*) Those which are provided with synovial sheaths, and

(*b*) Those which are not so provided.

If a tendon is cut or ruptured and remains within its protective synovial sheath, which is not severely damaged, provided infection does not occur, it will unite again by truly formed tendon tissue, provided, of course, that the severed ends are held in contact or within a short distance of each other, and probably it will regain the greater part of its mobility. In the case of tendons not provided with synovial sheaths the repair is less perfect, as the tendon is only replaced by fibrous scar tissue.

The operations performed upon tendons are as follows :—

(A) **Tendon Suture.** This is usually performed upon tendons divided either accidentally or at operations and is described on p. 381. It is important to sew the tendons with strong material such as chromic catgut or, better, silk, the ends being brought into neat apposition by mattress stitches assisted by one or more long tension sutures. We must emphasise the necessity for early movements to prevent adhesions in the sheaths.

(B) **Tenotomy.** This operation consists in cutting tendons across, in cases where they are too short and are producing deformity or resisting the reduction of some displacement, such as a fracture. Nowadays the operation is seldom performed and usually can be replaced by tendon lengthening (see below). In some cases muscles and fasciæ also will need division. The operation can be performed in two ways, (*a*) subcutaneous, (*b*) open.

(*a*) *Subcutaneous Tenotomy.* This is only performed in situations where there is no likelihood of damaging other important structures. Under the most careful aseptic precautions, a small sharp tenotome is introduced through a puncture in the skin and either over or under the tendon. The tendon is rendered taut by manipulating the limb and cut through by a sawing movement, when it can be felt to give way with a snap. If possible the tenotomy should not be done within a synovial sheath as the tendon will retract too much, while in any case the tendon sheath itself should be divided as little as possible in order to limit tendon retraction. After the operation a small dressing is applied with a retentive apparatus to hold the part in an overcorrected position, as without this reunion of the tendon and further contraction will occur. Some surgeons prefer to do the operation with two tenotomes, the skin being punctured with a sharp one and the tendon being cut with a blunt one introduced through the puncture.

(*b*) *Open Tenotomy.* In many cases, especially if important structures are close to the affected tendons, subcutaneous tenotomy is risky, and then the operation should be performed by an open incision and free dissection, an incision about an inch long being made and subsequently sutured.

After a tenotomy passive movements may be commenced at the end of ten days and active movements in sixteen days. If it is thought likely that further contraction will occur after reunion of the tendon, as in spastic cases, a portion of the tendon may be removed bodily. The tendons on which the operation is most frequently performed are :—

(*a*) The tendo Achillis. This may be severed safely by the subcutaneous operation.

(*b*) The sternomastoid, for congenital torticollis. Here the open operation is essential, as other muscles besides this structure will need division (Vol. II., Chapter X.), and the large vessels of the neck will need protection.

(*c*) The biceps of the leg may need division. This must be done by the open operation on account of the danger of dividing the external popliteal nerve.

(*d*) The tibialis anticus, which is usually divided about an inch above its insertion, on the scaphoid bone. This may be done subcutaneously.

(*e*) The tibialis posticus, which is usually divided just above the internal malleolus, together with the flexor longus digitorum. Care must be taken not to damage the posterior tibial vessels.

(*f*) The peronei tendons, which should be divided just above the base of the external malleolus by the subcutaneous operation.

(*g*) The semimembranosus and semitendinosus tendons, which are also divided subcutaneously just above the knee joint.

(C) **Tendon Lengthening.** This operation in many cases is done instead of tenotomy, as it is just as simple to perform, and its results are better. There are several different ways of effecting it. The older method consisted in exposing the tendon by an open incision, severing it, turning down flaps and suturing them together with silk stitches. A more satisfactory operation, however, is that known as the Z operation, the tendon being split longitudinally into two halves for a sufficient distance and then cut half through at either end of the split in opposite directions; the flaps are then drawn as far apart as required and sewn together firmly. Though this is usually performed by means of an open incision, it is quite easy to do it subcutaneously; two punctures are made in the skin from one to two inches apart, one half of the tendon divided on opposite sides at the level of each puncture; then by forcibly stretching the tendon the two halves can be made to slide upon each other the required amount without actually separating.

(D) **Tendon Shortening.** This is an operation not often required, but it may be necessary in the case of overstretched, temporarily paralysed muscles. The Z method may be employed here as already described, the union being made with silk stitches, and the two halves being shortened. In other cases the tendon may be cut across obliquely, a short portion of it removed, and the ends then sewn together again.

(E) **Tendon Transplantation.** This is an operation frequently performed for various deformities of the limbs. The term implies a detachment of a tendon from its attachment at one point and its transference and reinsertion to some other bone, tendon or strip of fascia, where it may be fixed by several methods, either by suture with silk, by tunnelling a bone, drawing the tendon through the tunnel and fixing it, or by metal staples, bone pegs, etc.

In other cases tendon grafting may be performed, various tendons being grafted or sewn together in order to help a weaker muscle by the action of a strong and healthy one, to alter the line of action of a muscle, or to make use of weakened and paralysed tendons as accessory ligaments; thus extensors may be transformed into flexors, pronators into supinators, etc., as the case may require. It is impossible to give detailed descriptions of such operations, as no two cases will be the same, and the procedure to be adopted must depend entirely upon the individual case. The two most important points in performing the operation are complete asepsis and absolute hæmostasis. Tendon sheaths must be resutured as far as possible, and careful fixation in an overcorrected position must be adopted for some time, a month at least. Massage, electricity and educational exercises must be employed freely after this, or even at an earlier date, provided they do not stretch the sutured tendons.

Before any such operations are performed, careful consideration must be given to the relative power and electrical reactions of the muscle groups concerned. The enlarged muscles seen in pseudohypertrophic muscular dystrophy have occasionally been regarded by orthopædic surgeons as a non-paralysed group and used for the purposes of transplantation into perfectly normal muscles. In addition to this, the value of the different movements, and especially the movements which will be lost by the tendon section, the origin of the nerve supply of the muscles concerned, and the synergic or opposing action of the muscle groups must be considered carefully. (See also p. 586.)

CHAPTER XXII

AMPUTATIONS—DISEASES OF AMPUTATION STUMPS —ARTIFICIAL LIMBS—EXCISION OF JOINTS

In this chapter it is proposed, briefly, to consider the main points of amputations and excisions, of the troubles met with in connection with limbs so treated and the artificial limbs necessitated by this type of surgical intervention.

AMPUTATIONS

As already indicated, the necessity for amputation indicates that the surgeon has failed either to cure or even check the disease, so that amputation has been defined as the last resort of the defeated surgeon, and so indeed it is; but let the surgeon, like a good general, be able to recognise defeat when it has occurred, so that he may be prepared by prompt amputation to remove a source of danger to the patient's life, where further conservative treatment can result at best in a useless and often painful limb.

The following general principles can be laid down in respect to all amputations:—

1. It is essential that sufficient soft tissues and skin be preserved to cover the cut end of the bone, and as the soft parts retract when they are cut, while the bone does not, they must be divided at a level below the point of bone section and freed from the underlying tissue up to this point.

2. Such skin coverings project during the operation and are known as *flaps.* To allow for shrinkage of the flaps and swelling of the tissues underneath the total length of the flaps together should be equal to one and a half times the diameter of the limb at the point of bone section or, what is practically the same thing, they may be equal to half the circumference of the limb at the seat of bone section. In order to ensure in so far as possible that they do not go gangrenous from insufficient blood supply, for this only can reach them through the attached base, they should be as short as possible and cut where practicable so that arteries run along their whole length; for these reasons a circular amputation, or the use of two equal flaps, is preferable in most cases to one long flap to cover the stump.

3. The question as to whether any muscle and tendon should be left over the bone ends is a controversial one, but we favour sewing some muscle across, as although this becomes fibrous tissue its presence prevents the bone end adhering to the scar in the skin (p. 725), and, moreover, the stitching of the opposing muscles does much to relieve the starting pains which are such a distressing and painful post-operative sequel to amputation while there is no need to leave so much muscle that a bulbous stump results.

4. The site of amputation must be determined by the condition and extent of the part to be removed and the necessity of preserving as useful a member as possible. Thus, although as a general rule every attempt should be made to conserve as much of the part as possible, especially in the fingers and hand, yet it must be remembered that an artificial limb approximating in shape and movements to the removed member must be fitted in most cases. In order to ensure the joints of this being on the same level as those of the opposite side, amputation must be carried out (through the bone) at least a hand's breadth (3½ inches) above a joint, but every inch of stump that can be saved above that is of value in forming a more efficient lever on which to work the new limb. In the hand, where no mobile limb can be provided, the principle of saving all tissue possible is the sole consideration, but above the wrist and the ankle the seat of election of amputation is in the situation named, *i.e.*, a hand's breadth above the joint.

5. There are certain points to be observed at operation:—

(*a*) The surgeon stands on the outer side of the right and the inner side of the left limbs when amputating above the ankle or wrist; he sits facing the sole of the foot when amputating through that or the ankle.

(*b*) Always when possible secure hæmostasis by a tourniquet applied over a towel well above the line of amputation; when amputating so near the trunk that this is impossible, secure the main vessels before cutting them (Chapter X., p. 293).

(*c*) Where two bones are present saw completely through the smaller first to prevent it snapping irregularly; always use long sweeps of the saw.

(*d*) Secure large and obvious vessels with ligatures, shorten nerves, and then remove the tourniquet and pick up smaller vessels which bleed.

(*e*) Sew up transversely in most cases, or else the pull of the flexors and extensors stretches the scar over the bone, and movements are painful.

(*f*) Always drain an amputation stump for 24–48 hours from its most dependent point as the patient lies in bed, through a counter-incision if necessary.

Of the various methods of performing amputation, the simplest and quickest is **circular amputation**, which consists in dividing the skin and subcutaneous tissue by a single sweep of the knife around the limb at a point situated at a distance equal to rather more than half the diameter of the limb (at the point of bone section) below this latter level. The skin is then freed and turned up as a collar and the muscles divided by one or two circular sweeps, so that as they retract up they are freed from the bone which is sawn through. The circular amputation is suited only to parts where there is one bone with a fairly even distribution of muscle around it, and it is, therefore, limited to the arm and thigh, where it is a most satisfactory operation.

Two modifications of the circular method to facilitate the retraction of the collar of skin are often practised, by making either one or two longitudinal cuts through the collar to facilitate the approach to the deeper tissues.

The Racquet amputation, with one cut, is practised at the metacarpo- and metatarso-phalangeal joints and at the shoulder and hip.

Equal flaps are formed when the two cuts are made, but inasmuch as the free corners are usually redundant and need removal, it is customary in amputating with two equal flaps to shape these in the first incision with slightly rounded corners, each flap equalling in length one-quarter of the circumference of the limb at the point of bone section, and its free end being that distance below the level at which the bone will be divided. Such flaps are usually situated anteriorly and posteriorly so as to secure a transverse scar, but in some situations, as the forearm, the blood supply may render the use of lateral flaps advisable. Such flaps consist of skin and subcutaneous fat only at their edges, but at the base contain muscle and fascia also.

Unequal flaps, one usually twice the length of the other, were used to get the scar clear of the bone end, but they are usually unnecessary, as the unequal pull of the flexors and extensors accomplishes this in most situations, and the contention that pressure occurs on the end of the stump in a pin and bucket limb is not correct (p. 725).

A single flap is not much used, as its very length renders its blood supply and vitality precarious, but if and where used it must equal in length the circumference of the limb at the point of bone section.

Transfixion Amputations where the knife is inserted first in front and then behind the bone and flaps cut rapidly by sweeping it down and outwards are not now practised (except in amputation of the terminal phalanges of the fingers), as the use of anæsthesia renders great speed unnecessary and of secondary importance to the securing of a well-cut flap and sound stump.

Guillotine amputations, *i.e.*, the division of all the tissues at the same level like a joint of meat, should *never* be practised. They were used in the war for gas gangrene, but the soft tissues retract and leave a raw conical stump with the bone protruding, which causes agonising pain and needs early reamputation, while equally efficient drainage and exposure can be obtained by a circular amputation, with the tissues left open; subsequently the skin can be sutured across the deeper structures when the infection has subsided.

AMPUTATIONS OF THE LOWER LIMB

In discussing these amputations, those in everyday use are described; for descriptions of those of historical interest, and the reasons for their having been abandoned, reference should be made to earlier editions of this work or text-books of operative surgery.

The toes, except the great toe, always should be removed by a racquet, with a dorsal handle, through the metatarsophalangeal joint: the head of the metatarsal is left untouched, as its removal damages the transverse metatarsal ligament and predisposes to dropping of the transverse arch of the foot.

The great toe should be preserved in so far as possible; the terminal phalanx may best be amputated by a transfixion anterior flap (p. 723), which preserves the plantar skin to cover the stump. The second phalanx, *i.e.*, the whole toe, should be amputated by unequal lateral flaps, the larger being the mesial one. In both cases disarticulation is performed through the joint.

If more extensive injury or disease be present, so that the foregoing amputations are not sufficient, then amputation through the ankle joint should be performed.

Syme's amputation is popular in England; the surgeon sits facing the sole of the patient's foot, which is over the end of the table, the leg being supported by an assistant. In the right foot the surgeon's left hand supports the foot, which is held dorsiflexed, his thumb resting just below and in front of the external and his forefinger half an inch below the internal malleolus; in the left foot the positions of the thumb and index finger are reversed. The knife is then carried transversely across the sole of the foot from thumb to finger, cutting down to the bone at the sides, but only to the surface of the plantar ligaments on the sole; this flap is then dissected back till the tendo Achillis is exposed and divided. The surgeon now grasps the fore part of the foot, which he strongly plantar-flexes, and with one sweep of the knife across the arch from malleolus to malleolus opens the ankle joint, and the foot comes away in his hand.

Another method of doing this is to make the two incisions as described above, marking out the flaps, and then to complete the disarticulation of the foot entirely from the front, shelling the os calcis out of the heel flap and cutting the tendo Achillis from the front.

The malleoli and articular facet on the tibia are sawn away, and after bleeding points, nerves, etc., have been attended to, the heel flap is pulled forward and sewn into position, being drained through a puncture in its most dependent part.

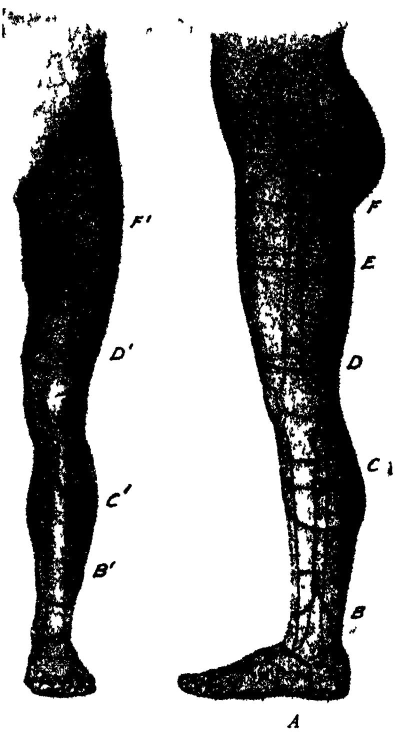


FIG 373 Incisions for amputations of the lower extremity. A. Syme's. B. B'. New seat of election. C. C'. Old seat of election. C'. Equal flaps; C. Farabœuf's external flap. D. D'. Circular through thigh. F. External. F'. Anterior racquet for disarticulation at the hip. E. Furneaux Jordan's amputation for the same.

Pirogoff's amputation is preferred by most Continental surgeons, and only differs from Syme's in that the tendo Achillis being divided, the posterior end of the os calcis is sawn off and left in situ attached to the heel flap, with which it is pegged to the sawn lower end of the tibia. This is an unsatisfactory operation and one only rarely performed.

In the leg only two amputations need description:—

Amputation at the "New" seat of election, two hands' breadth (or 7 inches approximately) below the anterior tibial tubercle, by equal anterior and posterior flaps, which extend down to just above the ankle. This gives a good bucket-bearing stump and permits of the use of an artificial ankle.

Amputation at the "Old" seat of election, a hand's breadth (or 3½ inches approximately) below the patella, the bone being divided just below the tibial tubercle; this may be done by equal lateral or antero-posterior flaps, or by a large external flap containing muscle (*Farabœuf's amputation*). The stump was not designed for a bucket, but to be flexed on a knee rest, and for this reason is too short and will kick over bucket in front on extension of the knee; thus it is seldom performed.

In the thigh a satisfactory artificial knee can be fitted only if the bone is cut at the junction of the middle and lower thirds.

THROUGH THE LOWER THIRD OF THE FEMUR the skin incision passes just above the patella if, as is usual, a circular amputation is performed. *Lister's amputation*, with a long anterior and short posterior flap, is also popular, but not necessary, as in the circular amputation the scar always gets drawn up posteriorly.

In the middle and upper thirds of the thigh a circular amputation should be performed.

The *Stokes-Gritti amputation* is performed by a large anterior flap crossing through the patellar ligament up to above the posterior part of the femoral condyles on each side, and a short posterior flap. The patella is left in the anterior flap, its articular surface cut away and the raw area pegged against the surface of the femur after the condyles have been sawn away.

AMPUTATION THROUGH THE HIP JOINT is usually undertaken for either advanced hip disease with sinuses, or sarcoma of the femur; it is a serious operation attended with grave shock, partly consequent on hæmorrhage from the sciatic and gluteal arteries, which are difficult to control, and has a mortality of about 20 per cent.

Furneaux Jordan's amputation should be used whenever possible, as it can be done in two stages, and leaves a solid muscle stump to which a limb can be fitted. It must *never* be used in cases of sarcoma.

The first stage consists in a circular amputation through the upper third of the femur, and here the operation may be abandoned if the patient is very ill, the second stage being performed some days later.

The second stage consists in making a longitudinal incision down to the femur on the outer side of the thigh, extending up to an inch above the great trochanter. The femur is forced outwards with the limb attached in a one-stage operation, and freed from muscles; the hip joint, thus abducted, is opened on its lower surface and disarticulated and the bone removed. The acetabulum is curetted if necessary, and the incision sewn up; needless to remark, the femoral artery is cut and secured in the incision around the thigh.

A **Racquet amputation** may be anterior or better external, as this latter permits of easier cleaning of the muscles from the dorsum ilii, which is so essential in the case of sarcoma of femur, for which condition this method is usually employed. The incision passes around the limb just below the perineum and across the trochanter, the femoral artery being secured before it is cut, and the muscles cleaned off the pelvis from within outwards, the hip joint being opened from below and disarticulated in abduction.

Interinnominate-abdominal amputation (hind quarter). This consists in removing the leg together with the innominate bone on one side, the abdominal contents being supported by flaps of muscle and skin. It is rarely required for large chondromata of the pelvis or femur.

AMPUTATIONS OF THE UPPER EXTREMITY

In view of the fact that no really useful and satisfactory artificial limb has yet been designed in the upper extremity, caution should be used in advocating ablation here, and especially in the fingers and hands, where, in cases of injury, every effort must be made to conserve any part which may be useful; if it proves not so it can be removed later. For this reason flaps of odd shapes, according to the nature of the skin injury, may be used, and therefore the " set " amputations must not be too slavishly adhered to by the surgeon.

Amputations through the Fingers and Thumb. Here every effort must be made to preserve as much tissue as possible, but if a stiff and useless finger results no hesitation need be entertained in removing it at the wish of the patient, who may find it an actual hindrance. Here especially set amputations must not be too slavishly followed, and much ingenuity may be shown in devising flaps; but remember bone must be covered, and do not make scars on the palmar aspect of the fingers or hand, as utility is impaired when pressure causes pain.

Amputation of the terminal phalanx is by a long palmar flap, and serves as the only example of a transfixion amputation now practised; the phalanx is flexed across the surgeon's left forefinger and the interphalangeal joint opened by an incision across the dorsum of the finger; the knife is passed to the palmar surface of the phalanx and carried forward to the tip, thus cutting a palmar flap, which is sewn over and gives a sound new end to the finger.

Amputation through the other phalanges or interphalangeal joints is usually by equal flaps or a dorsal racquet; provided the tendons are sewn over the end of the stump, there is no objection to amputating through the first interphalangeal joint or proximal phalanx, as movement is thereby ensured.

Amputation through the metacarpo-phalangeal joints, except in the case of the index finger, where a large external flap is preferable, is done by a posterior racquet incision. In ladies and professional men the head of the metacarpal should be removed, as the rest of the hand falls together and the deformity is less obvious; this is particularly the case in clerks where the right index finger is removed, as unless the metacarpal head goes also the thumb and middle finger do not approximate so satisfactorily to permit of the pen being held; in working men, where a strong hand is the most important consideration, disarticulation should be practised, the metacarpal heads and ligaments being left intact.

Amputations through the hand must be carried out with flaps designed according to circumstances; a part hand, especially if the thumb metacarpal is intact, is often most useful.

Amputations through the forearm are preferable, the seat of election being the lowest third; equal lateral flaps are best, as the vessels run at the sides, but antero-posterior ones can be used.

Amputation through the arm should be done in the lowest third if possible, and always by the circular method.

Amputation through the Shoulder (Spence's anterior racquet). The incision is carried down from the tip of the coracoid process and sweeps round the arm just below the level of the axillary folds, the artery being secured here before it is cut, and the shoulder joint disarticulated.

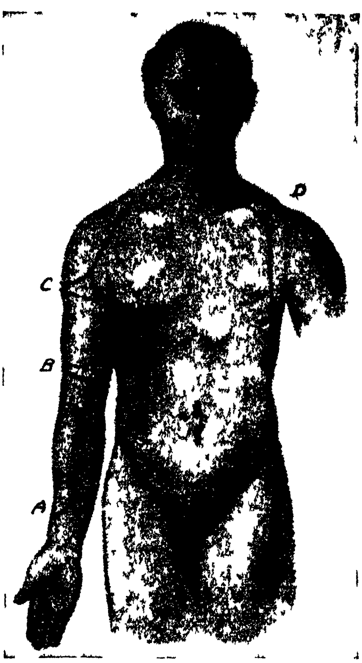


FIG 374 Skin incisions for amputations of the upper extremity. A. Forearm, equal lateral flaps. B. Arm (circular). C. Disarticulation through the shoulder. Spence's anterior racquet. D. Interscapulo-humero-thoracic.

Interscapulo-humero-thoracic (Forequarter) Amputation. This is used for removal of the upper limb with the pectoral girdle in cases of sarcoma, or where carcinoma of the breast exists with lymphatic œdema of the arm or involvement of the brachial plexus; in this latter case the incision described must be modified to allow of the skin flaps being formed from the back. The patient's shoulder is placed right at the edge of the table and supported by an assistant; the surgeon makes an incision along the clavicle, the middle third of which is removed to permit of ligature and division of the third part of the subclavian artery (Chapter X., p. 297), and at the same time the trunks of the brachial plexus may be injected with 1 per cent. novocain and divided; the incision is now carried down across the coracoid and inner end of the anterior axillary fold to the chest wall, and thence up and backwards across the middle of the scapular spine, across the shoulder to the coracoid again; the scapula is freed by dividing the rhomboids, serratus magnus, trapezius and certain small muscles and the limb and girdle removed.

LESIONS OF AMPUTATION STUMPS

(*a*) *Physiological.* (1) In children amputation stumps of the leg and arm which are satisfactory in every way will in course of time become *conical*, owing to the growth of the tibia and fibula and humerus, the upper ends of which are responsible for the main growth of the limb. Such a result is natural and will always occur in the course of time, a fact of which parents should be informed at the time of the original amputation. Treatment consists in reamputation and shortening of the bone, which may have to be repeated subsequently.

(2) **A Traumatic Neurofibroma** may be regarded as physiological, being normal nerve regeneration where the continuity of the fibres is interrupted; unless causing pain or discomfort it should never be excised, as another neurofibromatous mass will be formed in the cut nerve end.

(3) **Pain and tenderness** in the stump are to be expected for some months, and not infrequently referred sensation may give rise to an illusion that the limb is present still (*phantom limb*), which may cause a sleepy patient to attempt to stand out of bed on a non-existent leg, etc. In some cases the phantom limb may persist for many years.

(4) **Wasting of the Stump.** This is mainly due to disuse atrophy of the severed muscles, and will progress for several months; of course, no permanent bucket for an artificial limb can be fitted till the wasting has become stationary, when the stump is said to be "consolidated."

(*b*) *Pathological.* (1) **Infection** of the stump may occur at operation, when, (*a*) if the bone is affected, *septic osteitis* with necrosis and osteoperiostitis results (Chapter XVIII., p. 544); this usually leads to a red, swollen, painful stump with abscess formation. In old-standing cases a *sinus* or sinuses persist, and will remain open until the sequestrum has been removed. (*b*) The soft tissues may be affected, when *cellulitis* may occur among the muscles or subcutaneous cellular tissue, or *impetigo* of the skin. Should there be extensive infection, softening of arterial walls often leads to secondary hæmorrhage (Chapter IV., p. 51), while infection in the nerve sheath causes an inflammatory neuritis and is a potent source of painful stump.

(2) **Sinuses.** These nearly always mean that a sequestrum of bone is present, in which case a button-like granulation is usually present at the mouth of the track. An X-ray film will, of course, show the dead bone, which is usually of the typical conical shape (Chapter XVIII., p. 544). Occasionally a retained foreign body or a plug, swab or ligature left in at operation may cause a sinus to persist.

Treatment consists in exploration after an X-ray photograph and removal of the sequestrum or foreign body.

(3) **Painful Stump.** (*a*) Localised pain, definitely referred to one spot, is usually the result of infective neuritis or an adherent neurofibroma, either attached to the bone or muscle; occasionally the nerve has been cut too high, so that the neuroma is actually pressed on by the bucket, and this must be avoided when nerves are "retrimmed."

(*b*) Diffuse pain is usually the result of chronic infection of the bone with osteoperiostitis; often no actual sequestrum exists, but either condition can be diagnosed on X-ray examination.

Occasionally either type of pain is met with, especially in amputations through the thigh, due to the pressure of jagged, irregular, bony outgrowths around the end of the bone, such spicules apparently causing local irritation. They are usually the result of a mild infection.

Treatment. Prompt removal of "painful" nerve bulbs is indicated, care being taken not to trim the nerve so high that the limb bucket will exert pressure on the new "neuroma." Some surgeons advocate ligature and crushing of the nerve end to prevent reinfection, but this does not appear advantageous. In pain due to chronic bone infection reamputation some three to six inches higher up the limb is indicated. In some cases massage and hot-air baths are very beneficial. Mention should be made of pain of central origin which may occur as the result of long-continued peripheral irritation in neglected cases or be present from the first in patients who anticipate or, in the case of pensioners,

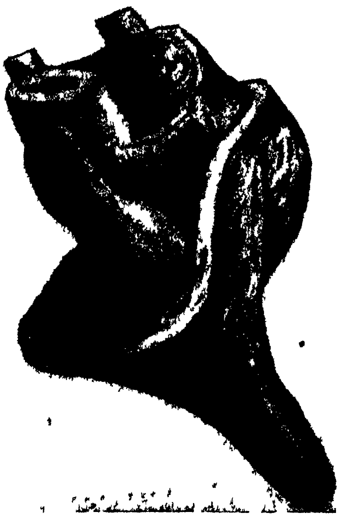


FIG. 375 Conical stump, following amputation of the humerus in a child, showing a large traumatic neuroma.

desire pain. In the former type division of the antero-lateral columns of the cord may give relief, but in the latter type no cure is likely to be effected.

(4) **Conical stump** results when the soft tissue flaps have been inadequate properly to cover the bone, which projects unduly under the retracted soft parts; as already mentioned, this occurs as a natural sequence to growth of the tibia and humerus in amputations through the leg and arm in children.

Treatment consists in reamputation.

(5) **Adherent and Unsound Scars.** (*a*) Adherent scars can be prevented in the vast majority of cases by adequate flaps, which should be united transversely so as to prevent the muscles stretching them across the bone, and also by always suturing the deeper soft parts, muscles, etc., across the bone stump. Adherence is unavoidable where the wound has broken down or a gaping wound has granulated, so that secondary suture should be undertaken if such a calamity occurs so soon as the sepsis clears up.

Treatment. Massage may be tried in slight cases, but reamputation at a higher level is usually indicated, especially if, as is often the case, the scar is also painful.

(*b*) *Painful scar* is often associated with adherence to the bone, but may occur apart from this as the result of chronic infection or the scar being anteroposterior and continually pulled on by the extensors and flexors in movements of the limb.

(*c*) *Ulceration* may occur from chronic infection, or as a result of inadequate blood supply in the flaps; this is often seen in paralytic limbs, and in amputations for gangrene where arterial disease is present. Friction on the scar, apart from infection, is only rarely a cause of the scar breaking down.

(*d*) *Sinus formation* through the scar, as already mentioned, is usually an indication of necrosis in the underlying bone.

Treatment. Palliative means may be tried, but reamputation is nearly always required.

(6) **Sloughing of the flaps** may result from inadequate blood supply or from infection, and in either case reamputation at a higher level should be carried out to prevent the formation of a conical stump and adherent scar.

(7) **Contracture of the joint above the amputation** is not uncommon and may prove a troublesome complication, as it prevents free movement and the wearing of a bucket. The condition may arise as a spasm due to irritation and infection in the stump, or persist as a fixed deformity from allowing the muscles to remain contracted or bandaging the stump in a bad position. It must be remembered that certain groups of muscles around joints are always stronger and tend to pull the joint into bad position, while the cutting of some muscles at amputation will permit uncut "opponents" to drag the joint into abnormal positions. These tendencies must be combated by position, fixation and extension, or tenotomies if necessary.

There is a tendency for the knee to flex after amputation of the leg, the hip to flex and adduct in thigh amputations, and the shoulder to adduct after amputation through the arm, thereby preventing the wearing in comfort and to the best advantage of a bucket for an artificial limb.

ARTIFICIAL LIMBS

From the foregoing it will be seen that in order to support an artificial limb to the best advantage, the amputation stump must be healed soundly, and the covering of soft tissues, although adequate, must be fully shrunken, while there must be freedom of movement and from pain. Experience has shown that a simple well-consolidated stump capable of bearing an artificial limb in which the shape and joints of the lost member are mechanically reproduced is more satisfactory than any of the ingenious motor stumps as designed by Putti and other surgeons.

The artificial limb needs to be sufficiently rigid to ensure support and utility and should reproduce in so far as possible the movements and function of the lost limb; while this has been very satisfactorily achieved in the case of the lower limb, no really good substitute for the upper extremity has yet been invented.

Artificial limbs are manufactured from either wood or metal, and may be solid or consist of a frame, to ensure rigidity, over which canvas or some fabric is stretched, while the bucket is usually made of leather.

The limb should be shaped to resemble the lost member, and joints in which leather thongs or rubber cords, worked by movements of the stump and body or by gravity, ensure mobility, should be inserted at the requisite levels.

The limb may be either "heavy," *i.e.*, approximating in weight the tissues removed, under the assumption that the central nervous system and muscles are geared to the movement of this weight, or "light," *i.e.*, as light in weight as is compatible with rigidity, as the cut and weakened muscles can move a lighter weight more adequately.

It is now generally conceded that light limbs are more comfortable and satisfactory, but some doubt exists as to whether metal frame limbs of some substance, such as duralumen, or hollow wooden limbs (best of seasoned black willow) are better. Probably the more complicated metal limbs are better, but certainly in uncivilised countries, where skilled workmen are not at hand, the more simple wooden limb is more stable under the stress of rough life and can be readily repaired by the local carpenter and blacksmith if necessary. The average life of either type of artificial limb is two years, and it is wise for a patient to have two in case of accidents.

The Bucket limb is now universally adopted, in place of the old knee rest when the knee was permanently flexed, and necessitates an extended stump, the pressure on which is around the sides and not at the end, which should not touch the bottom of the bucket. Owing to the necessity of allowing the stump to consolidate no permanent limb can be fitted for several (six to nine) months, but a peg leg with temporary plaster of Paris bucket, renewable whenever it becomes loose, can, with advantage, be worn so soon as the wound is soundly healed, as such a procedure hastens consolidation and accustoms the patient to an artificial limb. In any case, early and careful instruction in balancing, and the use of the joints, etc., of the new limb are essential if the patient is to get full use and advantage from the appliance.

EXCISION OF JOINTS

The operation of excision of a joint (*arthrectomy*) consists in the removal of a part, or more often the whole, of the tissues which form a joint; thus it comprises the removal of portions (usually as small as possible) of bone and also of the greater part of the cartilaginous articular surfaces, ligaments and synovial tissues, including such structures as intra-articular cartilages. The operation is performed much less often nowadays than it used to be, partly because other and less drastic methods of treatment have been introduced and partly because it has been replaced by less damaging and more efficient operations. The results aimed at may be to secure a movable joint (arthroplasty) or a fixed joint (arthrodesis), in which latter case the operation may be intra- or extra-articular.

The chief lesions for which excision of a joint possibly may be required can be enumerated as follows:—

(*a*) For tuberculous disease, where conservative methods have failed or other special features are present (see pp. 598, 604).

(*b*) In ankylosis of joints, especially if in a faulty position.

(*c*) For various injuries, *i.e.*, comminuted fractures, uncontrollable short fragments, detached heads of bones, etc.

(*d*) Occasionally for old-standing dislocations.

(*e*) For disease of the neighbouring bone ends, which are so damaged as to render the joint useless.

(*f*) To secure fixation and stability in a "flail joint" from paralysis of surrounding muscles, as in anterior poliomyelitis.

(*g*) For osteoarthritis.

There are three main methods of performing the operation:—

1. *The open method*, where the periosteum is left attached to the bone ends and it together with the ligaments, capsule, etc., are removed.

2. *The subperiosteal method*, which is really only a partial excision, and where the capsule and periosteum of the bone ends are turned aside, the synovial membrane and articular surfaces are removed with any other diseased structures, and the periosteum and capsule are then replaced.

3. *The osteoplastic method.* Here, in addition to detaching the periosteum, such bony prominences as tubercles, condyles, trochanters or tuberosities are temporarily detached and turned aside, together with the muscles attached to them. The necessary excision is performed and the bony prominences are then pegged, screwed or otherwise fixed back into place. This method has a very limited application.

The term "excision of a joint" must not be confused with the operation of *erasion of a joint*, in which all diseased structures, whatever their nature, are removed by curetting and snipping out with scissors without any formal resection of the bone ends.

The results aimed at in excision of a joint vary in different joints; in some cases, especially in the lower limb, firm ankylosis in a good position is what is usually desired, while in others, and especially in the upper limb, a movable pseudoarthrosis is aimed at. This may necessitate various modifications of the operation, such as *arthroplasty*, in which steps are taken to ensure a movable joint, and *arthrodesis*, which is devised to render fixed a joint previously mobile; for the details of these and further discussion on excision of joints, the student is referred to text-books on operative surgery and orthopædic surgery.

The Hip Joint. This is occasionally excised for tuberculous disease or for osteoarthritis or fractures of the head or neck of the bone. The operation usually performed consists in a partial excision, and it may be performed in three ways, either by the anterior or posterior incision, the latter being more suitable for extensive operations, and the former when it is only required to remove the head of the bone.

(A) *Posterior Incision.* In this case the patient lies upon the sound side, with the diseased hip slightly flexed: (*a*) an incision about 6 inches long is made commencing just below the great trochanter, and running upwards and backwards parallel to the fibres of the gluteus maximus as far as the posterior superior spine; the incision has a curve in it, concave backwards. The gluteus maximus is split and its fibres retracted and the interval between the upper border of the pyriformis and the lower border of the gluteus medius is sought, and at the bottom of this space the capsule will be found. The attachments of gluteus medius and minimus, the pyriformis, and the two obturators are separated from the femur as far as possible subperiosteally. The capsule is divided in a direction parallel to the pyriformis and the head of the femur dislocated through the opening thus made. The neck of the bone is sawn across and the diseased tissues removed as required. The after-treatment is the same as in the preceding operation.

The following is probably a better method:—

(*b*) A U-shaped incision is made crossing the base of the great trochanter, and this is exposed and detached with a chisel, together with its muscular attachments; the head and upper part of the neck of the femur and the capsule of the hip are thus exposed, and the joint can be opened and dislocated by adduction and internal rotation of the limb. An excellent exposure, both of the femoral head and acetabulum, is obtained by this method. The trochanter is re-attached by suture of the tendons and periosteum.

(B) *Anterior Incision.* The patient is placed on his back, with the selected hip near the edge of the table, and an incision 4 inches long is made, commencing immediately below the anterior-superior spine and running vertically downwards and inwards. The skin and deep fascia are divided and the interval between the tensor fasciæ femoris and the sartorius sought for and these muscles separated. Below these muscles the interval between rectus femoris and gluteus medius and minimus is found and these muscles separated, a small branch of the external circumflex artery being divided at this point. The capsule is then exposed and opened along its attachment to the anterior intertrochanteric line. If the joint is diseased it is best to saw through the neck of the bone in situ, when the head of the bone can be grasped with forceps and easily removed, but if the joint is normal, as when the operation is performed upon the dead body, the removal of the head from its socket may be exceedingly difficult, and it is then better to dislocate the head first by using the limb as a lever before sawing through the neck. As much as possible of the diseased synovial membrane is snipped away, the acetabulum curetted or gouged, and the wound is closed in layers. It should be fixed in a splint in slight abduction (20 degrees) and flexion (5 to 10 degrees), or in plaster of Paris for at least three months, and as in most instances it is hoped to obtain a firmly ankylosed joint, the patient will have to wear some form of splint or other support for about a year or even more.

Excision of the Knee Joint. This is one of the joints more frequently excised, a fixed joint being always desirable. The operation is usually performed either for tuberculous disease, osteoarthritis or ankylosis in a faulty position. The patient lies on his back and a curved horseshoe incision is made, convex downwards, commencing at the adductor tubercle, going down to the tubercle of the tibia and then passing up behind the external condyle. The skin and subcutaneous tissues are turned up in the form of a flap as far as the upper border of the patella, which is not included in the flap. The joint is then opened by a transverse incision either immediately above or below the patella; the former is the better, as the patella may then be turned downwards and held, thus serving to steady the limb. The subcrureal pouch and synovial membranes are dissected out, the joint flexed up and freely opened, the lateral ligaments and later the crucial ligaments being cut, and all synovial membrane and diseased soft tissues dissected away. With the joint acutely flexed the bone ends are protruded out of the wound, the soft tissues being elevated off them to a small extent by the elevator, while the infrapatellar pad of fat is dissected out. The knee is flexed so that the sole of the foot rests on the table and the lower end of the femur is sawn across in such a way that the bony surface left will be horizontal when the patient is standing erect. Care must be taken not to damage the epiphyseal cartilage, and as a rule not more than one inch of the bone should be removed. The semilunar cartilages are dissected away and the head of the tibia cleared and protruded from the wound; this is sawn across from before backwards horizontally, and as a rule not more than half an inch of the bone requires removal. Great care must be taken not to damage the popliteal vessels when cutting the crucial ligaments, the tissues at the back of the joint or completing the sawing of either bone. Some operators deliberately saw the bones so that, when they are brought into apposition, the knee will be in a position of slight flexion and genu varum. It is nearly always necessary to remove the patella, as it will be diseased, and this is cut away after the bones are sawn, while in most cases the bursa round the tendon of the popliteus should also be excised. The bones are then fitted together, and some surgeons make a practice of screwing, pegging or otherwise fixing them, though, in most cases, this is not necessary. The skin flap is sutured into position, and if much oozing is present a drain may be introduced for forty-eight hours. The limb is then placed upon a splint such as a McIntyre or plaster gutter, but it is only left upon this until the wound is healed and the stitches are out. As soon as this has occurred it should be encased in plaster of Paris so as completely to immobilise it for eight or ten weeks, by which time complete ankylosis, which is the object of the operation, should have occurred. It will be necessary, of course, for the patient to wear a high boot afterwards, and in many cases a walking caliper splint for six months or a year will be a wise precaution. Occasionally, an extra articular operation is performed.

Partial excision or erasion of the joint is an operation frequently performed; the same skin incision is made, but the ligamentum patellæ is cut through and the patella turned up in the flap, the joint being laid open; or this may sometimes be done by splitting the patella and its tendons longitudinally. All diseased soft tissues, such as synovial membranes, ligaments, semilunar cartilages, fat, etc., are dissected or curetted away and the bone ends also curetted. The joint is washed out and the wound sutured. It is put upon a splint for ten days, and when the wound has completely healed massage and movements may be commenced in an attempt to obtain a movable joint; but the results of the operation are not very satisfactory, as in most cases ankylosis follows.

The Ankle Joint. This joint is occasionally excised for tuberculosis, but the results of the operation cannot be said to be good. Partial excisions of various kinds are performed also occasionally in some varieties of talipes and certain cases of compound dislocation or fractures in the neighbourhood of the joint. There are several different methods of performing the operation, and a fixed joint is always aimed at.

(*a*) *Kocher's method* is performed by an incision which runs across the upper and outer surface of the foot, extending from the outer margin of the tendo Achillis round below the external malleolus, then across the front of the foot to the midline of the ankle joint. The veins and nerves on the front of the foot are retracted, the annular ligament is cut, and the tendons on the front and outer side of the ankle joint exposed. These tendons are retracted forwards and backwards, while in rare instances they will have to be cut and subsequently sutured. The anterior and posterior lateral ligaments of the ankle joint are then cut across, the joint opened on its outer and back side, the whole foot and ankle joint forcibly dislocated inwards, and the bone ends forced out through the wound. All diseased synovial and other soft tissues are removed and the bone surfaces are sawn away, while in many cases it will be necessary to remove the whole of the astragalus. The foot is then returned to its original position, the divided tendons and ligaments are sutured, the wound is sutured and dressings applied, the foot being held in full dorsiflexion.

(*b*) A complete incision across the front of the ankle joint from malleolus to malleolus, with division of tendons and retraction of anterior tibial vessels and nerve, is often employed and gives a good exposure, the foot being dislocated forward and all disease removed; the foot is then replaced, the tendons and skin sutured and the foot fixed in dorsiflexion as above. If necessary this operation can terminate in a Symes' amputation.

After both these operations the foot must be kept in full dorsiflexion in a splint for seven or eight days, until the stitches are removed; as soon as this has occurred, the foot and ankle should be encased in plaster of Paris, with the foot accurately at just less than a right angle, for six weeks; massage and movements should then be applied.

The Metatarsophalangeal and Interphalangeal Joints. These joints are frequently excised, the former for hallux valgus and hallux rigidus and the latter for hammer toe. The operation is best performed in the case of the big toe by turning outwards and downwards a horseshoe-shaped flap on the inner surface (see Chapter XXII., p. 704), while in the case of the other toes it is best performed by a single incision along the side of the toe. In hallux valgus only the inner side of the metatarsal head need be removed, a proceeding which saves damage to the transverse metatarsal ligament and consequent flattening of the transverse arch of the foot.

Excision of the Temporomandibular Joint. This is occasionally performed for tuberculosis and osteoarthritis, and also when the joint is ankylosed as the result of a preceding arthritis. The patient lies on his back with the head turned towards the opposite side, and the operation may be performed either by turning down a small flap just below the zygoma or by a horizontal incision 1½ inches long along the lower border of the zygoma and over the joint. Care must be taken of the auriculo-temporal nerve and the superficial temporal artery. The posterior border of the masseter will be seen, and this must be pulled forwards, while below and behind the parotid gland will be seen, and this must be retracted downwards and backwards. The capsule of the joint is then exposed and opened and the neck of the mandible set free by blunt dissection. The neck of the bone is then sawn through, care being taken of the internal maxillary artery below and behind it, and the condyle is seized and pulled out of the joint. Any other diseased tissues should be dissected away. In most cases the operation is only a partial excision. As it is of the greatest importance to preserve the mobility of the joint after the operation, in suturing the wound a flap of the masseter should be cut and turned into the joint to cover over the cut surface of the bone; massage and movements of the joint should be commenced in forty-eight hours.

The Shoulder Joint. In this joint a partial excision is usually performed, a varying portion of the upper end of the humerus being removed, while the glenoid is not usually interfered with, at most being curetted. The patient lies on his back with the shoulder projecting over the edge of the table and slightly raised, the arm slightly abducted and the surgeon standing at the outer side of the limb. A 4-inch incision is made from just outside the coracoid process and parallel to the anterior margin of the deltoid. The gap between the deltoid and pectoralis major is identified and the anterior border of the deltoid muscle retracted backwards, the cephalic vein being preserved; some surgeons prefer to split the deltoid in its anterior half. The pectoralis major is retracted downwards and inwards. The bicipital groove is then looked for and the capsule of the joint divided along the inner side of the biceps tendon, and this tendon carefully preserved, hooked out and retracted inwards. The arm is now alternately strongly everted and inverted, the following structures being cut through during these movements:—the anterior part of the capsule, the tendon of the subscapularis, the upper part of the capsule and the supra- and infra-spinatus muscles. All these muscular attachments to the bone can often be separated subperiosteally without actually being cut. The head of the bone is then forced out into the wound, the soft tissues being further divided, if necessary, as close to the bone as possible. A portion of the head of the bone is then sawn off, the line of section depending entirely upon the extent of the disease. In most cases this line lies between the anatomical and surgical necks. The synovial membrane, capsule, ligaments and glenoid cavity will then require dealing with by snipping away with scissors, curetting, gouging, etc. Drainage is usually unnecessary; the wound is closed, and a dressing applied with a good pad in the axilla. It is essential then to place the arm in plaster of Paris for six weeks, abducted at a right angle from the body, with the forearm horizontal and the tip of the elbow slightly in front of the shoulder. Fibrous union generally ensues, but if this abduction is preserved a useful shoulder results, as the scapula moves freely upon the trunk.

Massage and passive and active movements should be commenced as soon as the plaster is removed.

Other methods of excising the shoulder joint consist in a posterior longitudinal incision, the turning up of a U-flap, including the deltoid muscle, or sawing through the acromion. These methods do much more damage to the soft tissues, interfering especially with the deltoid and its nerve supply, while it is doubtful if they give any better exposure.

The Elbow Joint. In this joint a complete excision is usually performed. The arm is held across the patient's chest, with the surgeon standing on the affected side, and a 4-inch incision is made slightly to the inner side of the midline of the posterior aspect of the joint, parallel to the long axis of the limb, extending 2 inches above and below the tip of the olecranon and passing right down to the bones. With the periosteal elevator and knife the inner and outer halves of the triceps tendon and the origins of the forearm muscles on the inner and outer sides are detached. Great care must be taken to keep close to the bone, especially on the inner side where the ulnar nerve is lying in its groove, and if this part of the operation is performed subperiosteally the nerve will not be either seen or damaged at this point. The external and internal ligaments will require division, and when the joint has been freely opened the bone ends can be protruded from the wound. The ulnar nerve is also in danger during this process about 1½ inches below the joint where it is coming to lie in front of the ulna. The necessary amounts of the ends of all three bones forming the joint are then sawn off. As a rule the lower end of the humerus is sawn across the middle of the olecranon fossa, the whole olecranon and a shaving of the upper surface of the coronoid process is removed from the ulna, and the head of the radius is sawn off. The synovial membrane and soft tissues are snipped away as much as is necessary. In this operation we are aiming at a movable joint, and plenty of bone must be removed in order to decrease the chance of ankylosis. As a rule a gap of 2 to 2½ inches between the bone ends should be left. The wound is sutured without drainage and placed upon a splint. This should be an angular splint, which permits the movements both of flexion and extension of the elbow and supination and pronation to be performed without its being necessary to take the splint off. This is best achieved by means of a *Mason's Splint.* Slight passive movements can then be performed from the second day. The splint can be removed in ten days, and if massage and movements are persisted in a movable, strong joint should result. As this operation is bound to result in interference with the epiphyses of the bones, it should, if possible, not be performed until these epiphyses have nearly united, or deficiency in growth will occur.

An alternative method of performing the operation, that of Kocher, consists in a slightly curved incision, 5 inches long, on the outer side of the joint, the joint being opened on its outer side and the bone ends being protruded outwards. The remainder of the operation is performed as described above.

The Head of the Radius. The head of the radius not infrequently requires excision in old-standing fractures or dislocations; the head can be felt easily from behind and a vertical incision 2 inches long is made parallel to the long axis of the limb and over the most prominent part of the bone. The bone is cut down upon and the annular ligament is divided, care being taken to avoid the superficial and deep branches of the posterior interosseous nerve. The neck of the bone is then cut through with a fine saw, Gigli's saw or bone forceps, above the tuberosity of the bone, and the head is removed.

In any operation on the elbow joint the patient's occupation must be borne in mind in determining the position in which the joint should be fixed; as a general rule professional and clerical workers find flexion to well over the right angle, with the forearm in the midway position, the most useful, while in labourers and other manual workers the forearm should be fully supinated and only flexed about 20 to 30 degrees. In any case, where a rigid joint is aimed at, fixation in plaster of Paris for a month is advisable.

Excision of the Wrist Joint. This joint is an exceedingly complicated one, comprising as it does the joints between the radius and ulna, all the carpal bones and the metacarpal bones; usually six and sometimes five imperfectly separated synovial sacs are present. It follows, therefore, that excision of this joint is usually only partial and never likely to give satisfactory results, wherefore many surgeons advocate and practise amputations.

Should excision be performed the best method is by a transverse incision across the dorsum of the wrist, tendons being divided and resutured after the diseased structures have been removed.

Excision of the Metacarpophalangeal and Interphalangeal Joints. These operations are not often performed in the hand. A small incision about an inch long is made along the lateral aspect of the affected joint and with its centre opposite the joint line. The soft tissues are divided down to the bone and the periosteum and tendons pushed aside; it is then possible to force the ends of the bones out through the incision, when the required amounts may be sawn off.

CHAPTER XXIII

X-RAYS IN DIAGNOSIS AND TREATMENT

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IN dealing with the subject of the use of X-rays in diagnosis, it is of the greatest importance that the true position of the method should be realised. It should not be used with the idea of obtaining a diagnosis at short notice, but should be made use of to obtain a further light on the case in question. The clinician in charge of the case needs to get every possible view of it, and having exhausted his own methods he makes use of the various subsidiary departments. When their reports are received he can correlate his own findings with those of, say, the pathologist, the chemist and the radiologist, and by using them in this way he will gain the clearest possible view. The radiologist has only shadows by which to arrive at any conclusions, and though in some ways they may be exact, very often they are misleading. A further point, then, is that only men who continually work with this method are likely to be proficient in interpreting the evidence before them.

Physical Theories. It is not within the province of this chapter to go at any length into the physics of X-rays, save to say that they behave like ætherial waves which are stimulated by the bombardment of a metallic surface by a stream of electrons. These vibrations or waves in the æther have a definite relation in their wavelength to the ordinary visible spectrum. The longer known waves are those of wireless or Hertzian waves, which may be many hundreds of metres in length. The series then shortens down through the infra-red until all the visible wavelengths of the spectrum of white light are passed through, again past the violet or shortest visible wave into the ultra-violet, this being invisible to the naked eye, having a very definite irritant action on the skin, and having again a spectrum of its own. Beyond these ultra-violet waves the wavelength shortens more and more until the early " X " rays are produced. These waves themselves may vary very much in wavelength, and it has been found that the higher up the scale, i.e., the shorter the wavelength, the greater is the power of penetrating substances which ordinarily are practically impenetrable to waves of a length included in the visible spectrum. Ordinarily opaque substances are penetrable by X-rays in varying degrees, and their penetrability is in inverse proportion to their atomic weight. Thus the heavy metals and their salts are the most resistant to the passage of the rays, which is equivalent to saying that they absorb all but the most highly penetrating or shortest wavelength rays.

Production of X-rays. It is now necessary to consider broadly the methods of producing X-rays.

It has already been stated that X-rays are produced by the bombardment of a metallic surface by a stream of electrons. Supposing it were possible to isolate one electron, and that electron were to come into contact with the metallic surface at a given rate of speed, a ray of a definite wavelength would be produced. If the velocity of the electron were to be increased so that the impact was more sudden, the resultant wavelength would be shorter and, therefore, would have a higher penetration value. In the same way, a slower speed would give a longer wavelength and a lower penetration value.

These two opposites are spoken of loosely as *hard and soft rays*—the shorter wavelength and more highly penetrating rays being spoken of as "hard" rays, and those of long wavelengths and low penetration as "soft" rays.

From a practical standpoint a multitude of electrons has to be used, and it can easily be visualised that their speed will vary during each discharge according to the value of the motive power behind them. This power is derived from an electric current at a high pressure or voltage, and is supplied by either a large induction coil or, more usually under modern conditions, by a step-up transformer supplied by alternating current.

The pressure or voltage required varies with the work in hand, but may be taken to run from 60 to 150 kilovolts, where 1 kilovolt = 1,000 volts. In considering the electrical output of a step-up transformer supplied by alternating current it is necessary to visualise the type of current supplied to the machine, which is usually of a comparatively low voltage, say 100 to 240 volts. It is supplied from the generating dynamo in a series of sinusoidal waves, first in one direction, commencing at zero and building up to a maximum, then sinking again to zero and commencing to build up to an equal value in the opposite direction along the conductors, and falling again to zero in the second half. The complete operation in the two directions is spoken of as one cycle, and each generator gives a constant number of cycles per second, commonly fifty or sixty. These impulses of current are passed into the low-tension coils of the transformer, and by the consequent changes in the magnetic fields of the cores set up a current in the secondary windings, giving a greatly increased voltage.

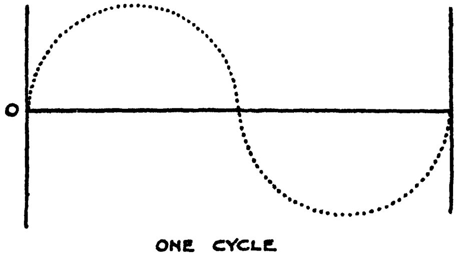


FIG. 376. Wave form of one complete cycle.

From the foregoing it can be seen that, as the voltage builds up, the supply of electrons will begin to move sluggishly at first, and gain enormously in speed as the peak is neared, then sinking as the current subsides again. X-rays are produced when the current reaches 30 kilovolts and upwards. The second half of the cycle is flowing in the opposite direction, and should it be allowed to act the supply of electrons would naturally reverse their direction. This would very soon tend to destroy the X-ray tube and would not, owing to the position of the various parts of the tube, give radiations in any useful direction, and, therefore, the so-called "inverse" current must either be cut out altogether or converted into the right direction by an automatic commutator, in the case of an alternating current, acting synchronously with the periodicity of the current.

X-ray Tubes. The next point is to consider the source of the electron supply and the outlines of the construction of an X-ray tube.

Tubes consist, broadly, of two kinds, and the original gas tube will be considered first.

(*a*) *The Gas Tube.* This type consists of a glass bulb, from 6 to 8 inches in diameter, blown on a length of tube of suitable size. In either end metal terminals are fused, connected with electrodes within the bulb. One of these, the *cathode*, is formed of a concave plate of aluminium, and is withdrawn just into the neck of the tube. Opposite to this is a heavy copper electrode carried on a heat-conducting metal sleeve, for purposes of cooling by radiation. The face of this electrode, which is spoken of as the *anode*, is cut at an angle of 45 degrees to the longitudinal direction of the cathode stem, and into its face is let a target of tungsten. Other metals have been used, as each has a slightly different characteristic radiation, but tungsten has been found most satisfactory, owing to its high atomic weight and melting point and toughness. The cathode is so arranged that the focal spot of its concave surface impinges on to the tungsten target of the anode. The tube is then sealed and exhausted to a high degree of vacuum, in the region of two-millionths of an atmosphere. In addition to the electrodes a small tube is sealed into the bulb, in which a small supply of gas is concealed which can be liberated into the bulb by the application of heat as the residual gases within the tube become used up. This is known as a regulator, and is an addition to lengthen the life of the tube. The main point is that the supply of elections is obtained from the residual gas within the tube.

On the passage of a current of a sufficiently high voltage to overcome the very large resistance of the tube the electrons are attracted across from the cathode to the anode or target, where they are focussed upon a spot by the concave cathode plate. From that point the rays are given out in straight lines in all directions from the face of the target, and the ray passing down at right angles to the electron or cathode stream is spoken of as the *incident or central ray*. In all radiographic work this ray is used as the centre line of the cone of rays.

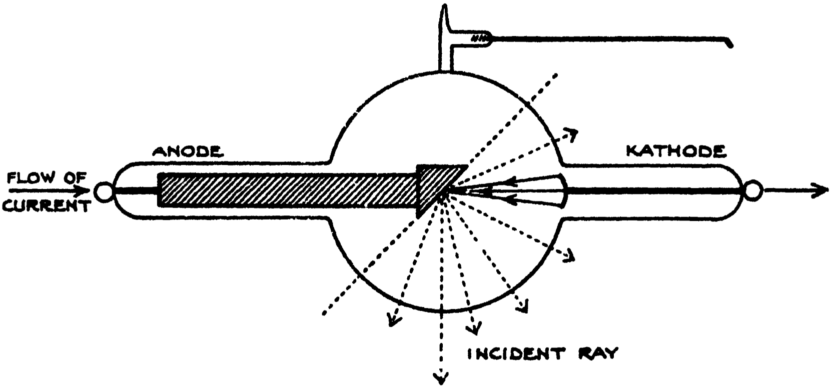


FIG. 377. Diagrammatic representation of the formation of X-rays by an X-ray tube.

(*b*) The *hot cathode tube* depends for its function upon the property possessed by tungsten of giving off ions when heated. The first tube of this type was invented by Coolidge, and for some years was the only one of this variety in common use. It is exhausted to a very much higher degree than the gas tube, and no regulator is needed. The anode and cathode are brought very much more close together, and the cathode is contained in a molybdenum cylinder with a flat spiral of fine-drawn tungsten wire. This filament is connected through its terminals with a source of low-tension current of about 12 volts, and is heated to incandescence by it. The heating current is under the direct control of the operator through a variable resistance, and the low-tension leads also act as the high-tension return lead to the machine. It will be readily seen that as the variations in heat cause a variation in the supply of electrons the condition of the tube is under a very perfect control while in action. The hot cathode tube has now by its greater ease of manipulation completely superseded the gas tube. Several varieties of this type of tube are now in common use all making use of this principle, the variations in design and arrangement of the various parts differing in order to distribute the focal point heating over a wider surface, at the same time retaining the effect of a small focus. The angle of incidence of the cathode stream is in some tubes only 20 degrees, the latest models of heavy discharge tube having a rapidly rotating anode. Some tubes have a dual focus and are additionally useful in small X-ray departments where one tube has to be used for all types of cases. All modern tubes are rendered " shock-proof."

Visualisation of Rays. It is now necessary to consider the methods of visualising the rays. There are two methods employed : photographically or indirectly, and optically by means of the fluorescent screen :—

(*a*) The former is possible by reason of the fact that silver salts in emulsion are acted upon by X-rays exactly in the same way as by exposure to ordinary visible light. When an object such as a part of the human body is interposed between the source of rays and the sensitised film, a certain percentage of rays is absorbed in that object. Where parts of that object are composed of varying densities of tissue, the heavier parts will absorb more rays than the lighter. Therefore behind those denser parts less radiation will be available at the film to cause the alteration in the emulsion, and a negative shadow will result in the fully-developed film.

(*b*) The use of the fluorescent screen is a method of visualising the same process.

A sheet of prepared cardboard is coated with an emulsion containing a salt in a finely divided state which has the property of fluorescing when under the influence of X-rays. The salt originally used for the purpose was barium platinocyanide, in the form of small crystals. The salt now used is calcium tungstate. The former gives a green fluorescence, and the latter a blue. Of late compound salts have been used, which last well and give great brilliance.

The fluoroscopic method is ordinarily used for visual examination in the following types of cases :—

1. As an adjunct in gastro-intestinal work ; particularly essential in regard to the œsophagus, stomach and duodenum, and also in cases of opaque enema.
2. In the thorax for the estimation of lung expansion, and the control of artificial pneumothorax. In cardiology to estimate the size, shape and movements of the chambers of the heart and the large vessels. Also in orthodiagraphy.
3. To determine the presence of foreign bodies in the respiratory or alimentary tract, and to locate them.
4. To localise foreign bodies that are sufficiently opaque anywhere in the body.
5. To facilitate the reduction of fractures and dislocations in certain difficult cases.
6. To establish the patency of the Fallopian tubes.
7. Occasionally in retrograde pyelography.

Standard Technique. In practice it has been found desirable to work out a standard technique so that all skiagrams are comparable, more especially if subsequent examinations are undertaken to watch the progress of a given case. Thus the two views taken are from front to back (or the reverse), and from side to side or laterally, the limb at the time being held as far as possible in a true anteroposterior or lateral position. In cases where great pain attends fixation of the limb in the true position note must be made of the approximate amount of deviation from the normal required to enable examination to be made without causing distress. No patient should ever be examined in such a position that he is in pain or that any muscular action is required to maintain that position. Where this is the case a certain amount of muscular tremor is given to the limb, and though gross lesions can be seen the fine structural detail so necessary for visualising small lesions will be lost.

Stereoscopic Pictures. There are several parts and groups of bones, however, to which the foregoing technique is not applicable. In such a case it is necessary to take two films stereoscopically. To carry this out a changing box is placed beneath the part to be examined, so that the first film may be removed and a second placed in position exactly as the first. The tube is placed above the part, so that the incident ray passes through the site of the lesion. The tube is then moved 3 cm. to one side and the exposure made. A second film is put in place of the first and the tube again moved 6 cm. in the opposite direction, i.e., 3 cm. to the other side of the centre point, and the second exposure is made. The total tube shift of 6 cm. roughly represents the distance between the normal eyes. The films, after development, fixation and washing, are placed in a special stereoscope, each eye viewing one film in a separate mirror, which is moved until the images are superimposed, and the various components of the part X-rayed will be seen to stand out in their true relationship. This method is reasonably accurate, but where any doubt exists it should be repeated from a different position for confirmatory evidence of a suspected lesion. The foregoing methods of examination are suitable for all parts where there is no great thickness of tissue surrounding the bone. In dealing with the deeper structures a more complicated method must be employed.

Secondary Radiations. It has been found that upon the passage of X-rays through any body a form of characteristic secondary radiation is stimulated in that body. It is obvious, therefore, that where skiagrams are required of any thick part of the body, such as the lumbar spine or hip joint, it will be necessary to allow more time for the passage of rays through the part owing to the very much greater absorption of rays by the greater quantity of tissue. If it were not for these secondary radiations, which, stimulated throughout a large area of tissue, pass out in all directions, the time factor would not be so important. As it is, the longer the time of exposure, the longer time do the low-penetration secondary rays have to act upon the film, giving the effect of a mild fog partially obscuring the image and completely obliterating the fine bone detail. In view of these facts two important methods have been devised, firstly for greatly diminishing the time of the exposure, and secondly for cutting out all but a very few of these secondary rays :—

(*a*) *Accelerating Screens.* The first method is the use of specially prepared accelerating screens. These are made of fine grainless cardboard on which is a chemically even layer of fluorescent salt, usually a preparation of calcium tungstate, which on being stimulated by X-rays fluoresces bright blue. As in the case of the radioscopic screen, shadows are brought out by the more dense structures. The film, sensitised on both sides, is placed between two such screens and is forced into contact with them by springs in a special cassette, not unlike an ordinary photographic printing frame, except that the front, through which the rays must pass after leaving the body, is composed of a thin layer of aluminium through which rays can pass easily. The action of the screens can readily be understood. The photographic film is particularly sensitive to blue light, and the vivid blue fluorescence of the screen caused by the ray stimulation is imprinted on the sensitive medium as ordinary visible light. In this way the time of exposure is cut down to even as much as one-tenth of what would be required for unscreened films.

(*b*) *The Potter-Bucky Diaphragm.* The second method is by the use of the Potter-Bucky diaphragm combined with the double accelerating screen technique.

It should be understood that the function of this machine is purely that of cutting out secondary radiations stimulated by the passage of X-rays through the body.

These secondary radiations, passing in all directions, have the effect of blurring the image reproduced on the sensitised medium in much the same way that would occur should an ordinary plate, exposed to light in a camera, be at the same time affected by a very slight leakage round the setting of the lens.

The method adopted in this diaphragm for cutting out these undesirable rays is briefly as follows: A large number of strips of thin lead foil, roughly 2 feet long by 1 cm. broad, are placed side by side and longitudinally parallel with one another, and at a distance apart of 0·5 mm. They are held apart by packing strips of some suitable non-opaque material, such as soft wood. The whole of this formation is so curved as to form a segment of a circle of a 25-inch radius—the lead strips each forming the last centimetre of a radius. The patient is placed so as to lie in the concavity of the formation, and the sensitised film is placed below it. The focal spot on the target of the tube is then placed above the patient at the centre of the circle, i.e., 25 inches above the diaphragm.

In actual practice it was found that very good skiagrams could be taken in this way, but each had the pattern of the grid superimposed upon it. To obviate this the patient was supported a very short distance above the diaphragm, and an arrangement was incorporated by which the grid between patient and film could be made to move at any desired speed. The action of the grid will be seen thus. All radiations travelling direct from the focal point of the tube radially will pass either through the spaces between the lead slats or a small proportion will be absorbed by the lead slats themselves. The lead slats will not be shown upon the film, as they are moving, but they will cut out a certain percentage of the rays carrying the image, thus requiring a slight increase of the exposure to produce that image. Further, all the secondary radiations from the body tissue, not passing along the radii of the circle, will impinge upon the lead slats laterally and will be absorbed. This gives an outline of the principle upon which the machine works.

A recent advance is the all-metal fixed grid which is composed of very fine lead slats set in a non-opaque metal. Although the pattern of the grid is superimposed on the film the grid lines are so fine as not to interfere with the interpretation of the film. This grid is of use in ward work and in cases where the moving grid is not practicable.

The use of the double accelerating screen is invariably necessary with this apparatus, and the time of exposure will be multiplied by approximately four.

Radiographic Examination of the Body. It is now necessary to consider in some detail the radiographic examination of the various types of structure of which the body is composed, remembering that their visibility depends upon either their density in relation to that of surrounding structures or upon their ability to be filled out by some substance rendering them either more opaque or more translucent than their immediate surroundings.

That structure which comes most naturally under first consideration is bone. It is intended in the ensuing pages to deal with each system from the point of view of demonstrating the methods used and the pitfalls which beset the unwary. Throughout the text will be found many skiagrams dealing with diseases under their appropriate headings.

THE BONES

In making examinations of any bone structure it should be borne in mind that the photographic method is the only one upon which reliance can be placed. It is little better than useless to examine with the fluorescent screen, as the eye is unable to detect small abnormalities, and only very gross lesions can be visualised. Conditions such as subperiosteal cracks or impactions with little deformity will invariably be missed. To bring out the relations of fragments in a fractured long bone it is necessary to obtain two views of the injured part. The tube is placed above and the film below, and the incident ray is arranged to pass as nearly as possible through the site of suspected injury. The part is then rotated through a quarter of a circle and the process repeated, the resulting skiagrams giving two views at right angles. From these the exact relationship of the fragments can be seen.

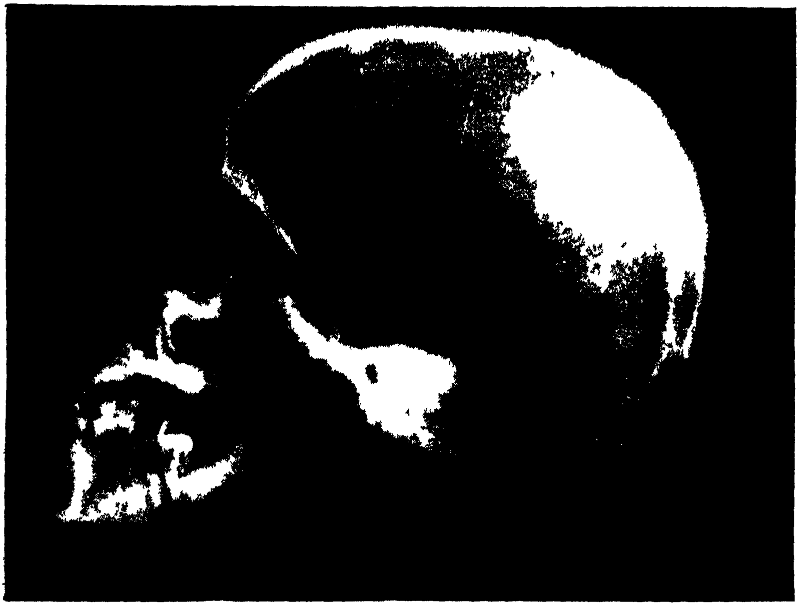
There is no need to dilate upon methods of radiographing long bones, but it is necessary to give brief consideration here to the various joints and special regions.

The Skull. The first of these is the skull, under which come the vault, base, facial bones, air cells and teeth.

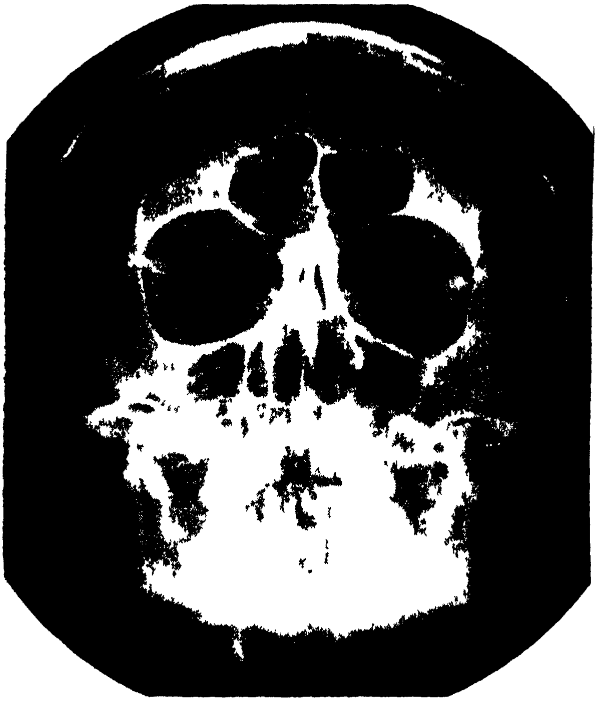
(*a*) *The Vault.* The vault is best seen by two views taken at right angles, i.e., posteroanteriorly and laterally. In the former the face is placed against the film with the forehead and nose in contact with it, the chin being usually slightly raised, the tube being above and the incident ray passing through in the region of the occipital protuberance. For the lateral view the head is turned sideways, so that the median plane is parallel to the film, the incident ray passing downwards at right angles to the film 2 inches above and 2 inches in front of the external auditory meatus. In the case of a suspected depressed fracture the head may be turned for a third film, so that the central ray passes through the suspected area in profile.

(*b*) *The Base.* Skiagrams of the base of the skull are best taken stereoscopically with the head in the true lateral position, but where the sella turcica is suspected the central ray should be directed through that point. The centering point for the sella is ½ inch above the midpoint of a line joining the outer canthus of the eye with the antitragus of the ear. In this case, where a profile of the sella only is required, one film is sufficient, and it has been found that a small, cylindrical diaphragm giving a small circle on the film of 3 inches diameter gives a very clearly-defined image of the sella, the heads of the mandibles, which should be superimposed as nearly as possible, and the sphenoidal sinus, whose roof is in part composed of the floor of the sella. An infra-superior view will show the whole base if the patient can be placed in the desired position. The patient should be supine with the shoulders

PLATE IX.



The normal skull, showing the sella turcica.



Antero-posterior X-ray appearance of the normal skull, showing the air sinuses.

raised and the head hyperextended to the maximum extent with the summit of the vault resting on the Potter Bucky diaphragm. The central ray passes through a point midway between the angles of the jaw.

(*c*) *The Face.* The bones of the face and orbits are difficult to demonstrate individually owing to the surrounding and overlying structures. By careful positioning, however, with the patient in the erect position and the use of a cone valuable information is obtained.

(*d*) *The Air Sinuses.* The air cells contained in the skull are of the greatest importance, and very often in inflammatory lesions or malignant growths a skiagram may be of the greatest help. The method is to take a skiagram of the skull in such a way as to show them in their bilateral symmetry, and from variations in their opacity pathological conditions may be deduced. *Empyema of the air cells* of one side will show a marked increase in opacity, with some blurring of definition of the outline, and in extreme cases, such as a mucocele of the frontal sinus, the destruction extends even to the orbital margin. In new growths the translucency is impaired, and at an early stage may be mistaken for an inflammatory lesion. Later, as the disease extends, the margin is seen protruding beyond the air cell in question. There is a simple technique to obtain a skiagram on one film, showing all but the sphenoidal sinus.

The patient sits upright in an adjustable chair facing a vertical stand carrying the cassette. The head is brought into contact with the cassette in the desired position and clamped in place. The tube is brought up behind and an extension of cylindrical metal tube of 6 inches diameter and about 10 inches long is pressed on the back. For the sphenoidal sinuses the head is extended to the maximum amount possible and the tube centered over the cranial summit and angled downwards so that the incident ray passes through the sphenoidal cells. A Bucky diaphragm is embodied in this device, but it has been found that without its use finer shades of opacity are visualised than with it, this being usually of more importance than very pronounced bone detail, and also reducing the exposure and minimising the likelihood of tremor.

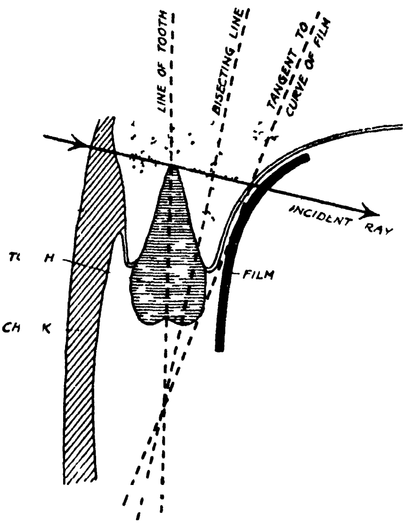


FIG. 378. Diagram of a tooth in the jaw with the various lines and the angle at which the incident ray should impinge.

(*e*) *The Teeth.* The radiographic examination of the teeth is of great importance, and is carried out with small films, of 1 by 1¼ inches, wrapped in light waterproof wrappers and placed within the oral cavity.

The whole of a healthy adult set of teeth may be taken on ten of these films, or occasionally it may be better to use twelve or fourteen. The films are flexible and are placed by the operator in the patient's mouth so as to fit to the wall of the palate and follow its curve. The patient then is instructed to press the film firmly into place with the thumb, taking care that the fingers outside do not get between the outside of the teeth and the tube, or their image will be superimposed on the film. The films are placed in position in turn, one for the molars, one for the bicuspids and canine, and one to include the incisors, each film being numbered immediately in accordance with a prearranged plan.

In the upper jaw the most difficult part of the technique is the placing of the tube in the correct position to give the whole image of the tooth on the film with the least possible distortion. The ideal at which to aim is that the central ray shall be at right angles to a line bisecting the angle between the centre line of the tooth and the tangent of the curve of the film, passing through the apex of the root of the tooth. This is a counsel of perfection and is exceedingly difficult of attainment, but, bearing this in mind, there is less risk of distortion of the image or of missing the apex of the tooth on the film.

In the lower jaw the film lies more flat and is held in place with the forefinger, and there is little risk of much distortion save in the incisor region where the tube must be angled acutely to obtain the apices.

Many devices have been brought out to retain the films in position, but in general it has been found that holding by the patient is best, and least liable to mislead the operator; it also gives least discomfort to the patient.

The Spinal Column. The next series of bone structures to come under observation is the spinal column. This is divided anatomically into cervical, dorsal, lumbar, and sacral and coccygeal regions, and under those subdivisions it is usually considered by the radiologist.

(*a*) *The cervical spine* is of special interest, as it has the articulation of the skull dependent upon it and also the special device between the first and second vertebræ to allow of the free turning movement of the skull. At its lower limit is the seventh cervical vertebra, whose main radiological importance is the occasional presence of an extra pair of ribs which may give rise to lesions of the nerve supply to the upper extremity. The examination, as a whole, should consist of two views at right angles, anteroposteriorly and laterally. The lateral view should be made with the patient standing or sitting. In the anteroposterior view, two films of the upper six vertebræ must be taken, as the lower jaw obliterates the upper two. From the fourth to the sixth a simple exposure is made in the ordinary way, but to get a skiagram of the occipito-atlantoid and atlanto-axoid joints the patient lies supine as before, but has the mouth widely open, the central ray passing downwards through the mouth. In this way a clear view is obtained of the two joints in question.

The seventh cervical vertebra is important chiefly in relation to cervical ribs, as has already been pointed out.

(*b*) *The dorsal spine* is subdivided radiologically into the upper four or five vertebræ and the remainder down to the twelfth. The anteroposterior view of the whole may be done on one large film of 15 or 17 inches in length. An exposure is needed sufficiently long to penetrate the heart and mediastinal shadows and show clearly the definition of the bodies. The lateral view of the lower seven bodies is straightforward, but the upper two are unobtainable in a true lateral position, by reason of the shoulders overlapping them, and the best that can be done is an oblique view, which is far from satisfactory at the best.

(*c*) *The lumbar spine* examination is straightforward, but, as it is overlaid in front by the abdominal contents and laterally by large masses of muscle, rather special technique must be employed. In the former it is advisable, where feasible, to have the patient's alimentary canal as empty as possible, and purgation beforehand is advised.

The lateral view is easily obtained, though a ray of higher penetration value is required and a rather longer exposure needs to be given. When an upright Potter-Bucky diaphragm is available all lateral views of the dorsal and lumbar spine should be carried out in the erect position. This enables undistorted views of individual areas to be made.

(*d*) *The sacrum and sacroiliac joints* are best shown by centering the incident ray midway between the two anterior superior spines of the ilium. A lateral view is obtainable through the buttocks, and is particularly valuable in recognising coccygeal displacements. Gross lesions of the sacrum are rare. The coccyx is best seen by centering the tube as for the sacrum, but directing the incident ray slightly downwards. Previous to the examination an enema simplex is advisable, as masses of fæces in the rectum may completely obscure this bone. A lateral view of the coccyx is of great use in suspected displacements and is simple to obtain. Place the patient on his side and centre 2 inches behind the great trochanter of the femur, with the thighs flexed. A comparatively long exposure is required owing to the large masses of muscle in the buttocks.

The Upper Extremity. The upper extremity may be taken to include the clavicle, and where this bone comes under suspicion the most satisfactory method to use is to lay the patient face downwards on the cassette and bring the shoulder and sternal ends of the clavicle into apposition with it by raising the uninjured side on a pillow. The tube is centered above the approximate centre of the bone behind and the exposure is made during cessation of respiration. This view gives good detail and is in one plane only. Should a displacement be suspected after injury stereoscopic views may be taken as already described, but it is usually sufficiently plain to the clinician without needless labour and expense in the X-ray department.

(*a*) *The shoulder joint* is examined from front to back, and to obtain the relationship of different parts, stereoscopically. The cassette is placed behind the joint and the incident ray is centered over the head of the humerus, just external to the coracoid process of the scapula. Injuries to this joint are common, and that most frequently seen is fracture of the surgical neck of the humerus. A later view may be taken by placing a film in contact with the lateral aspect of the shoulder and at an angle of about 75 degrees to the broad plane of the scapula. The central ray should pass at right angles to the film through the fifth dorsal vertebra. This view shows the humerus and scapula in a lateral aspect and thrown clear of the bony thorax.

(*b*) *The elbow* is examined by two views, anteroposteriorly, centering over the midpoint of a line joining the two epicondyles, the incident ray passing through the antecubital fossa, with forearm supine and fully extended ; and laterally, with the joint flexed to a right angle, the cassette below the inner side and the central ray passing through the upper end of the radius, with the hand resting on the ulnar border and the full length of the humerus parallel to the plane of the film.

(*c*) *The wrist joint* is best examined from behind, with the hand prone on the cassette or unscreened film. The incident ray should pass through a point midway along a line joining the spinous processes of the radius and ulna, which may be felt. This view gives the entire wrist joint and carpal bones. The lateral view should be taken with the hand resting on its ulnar border at right angles to the film, and the centre point is over the tip of the radial spine. (See Plate XI.)

(*d*) The examination of *the long bones of the arm and the digits* is a matter of no difficulty, and the operator will be guided as to the centering by the suspected site of injury, care being taken that plenty of bone on either side of this point is included. Should the injury then appear far out of centre a second examination of the actual lesion is a matter of no difficulty.

The Lower Extremity. Examination of the lower extremity commences with the hip joint.

(*a*) *The hip joint.* The standard technique employed brings in again the use of the Potter-Bucky diaphragm, as the surrounding muscular tissue is very thick. The joint is examined with the central ray passing through the head of the femur, which is found 1 inch below the midpoint of a line joining the anterior-superior spine of the ilium to the symphysis pubis. Usually one skiagram is sufficient, and it should show all the bone structures, but in cases where intracapsular fracture or any fracture of the upper end of the bone is suspected, including the upper third of the shaft, stereoscopic films must be taken. (See Plate X.) Where a fractured neck of femur has been established by the above methods it will be necessary to obtain a lateral view of the site of fracture. To do this the patient's sound leg is flexed up out of the way and a " shock-proof " tube is brought below it and in contact with the perinæum. The incident ray is directed upwards and outwards in a line midway between the anterior superior iliac spine and the greater trochanter, in the body plane. The cassette is placed at the level of the iliac crest and parallel to the femoral neck.

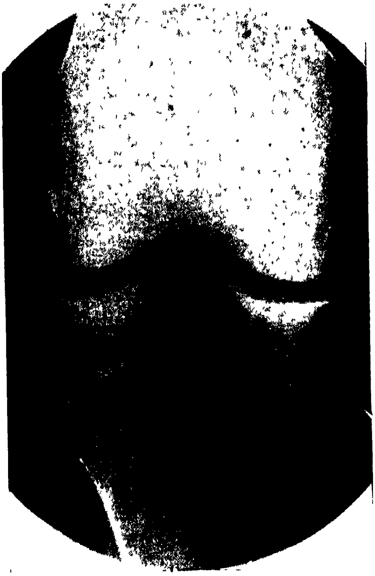
This method is coming largely into use in connection with operations dealing with the pegging of the fragments in fractures of the neck.

(*b*) *The knee joint* presents no difficulty to the technique of two views at right angles, and the points to be remembered are that, where the patella is under consideration, the film should be in contact with that bone, i.e., the patient will, if possible, be face downwards, and the tube will be behind, centered over the centre of the patella. Normally, where the knee joint is required, the tube is centered in front over the lower pole of the patella with the film behind. This centering ensures that the incident ray passes through the joint. The position of the leg is important, and the patella should lie exactly central between the condyles of the femur. To attain this it is generally necessary to rotate the foot slightly inwards until the patella comes into position. The lateral view of the knee joint is of great importance, and it should be taken in very slight flexion. The heel is raised slightly on a sandbag, and the central ray is passed between the internal tuberosity of the tibia and internal condyle of the femur, the film lying beneath the outer side of the joint, with the patient lying on the affected side.

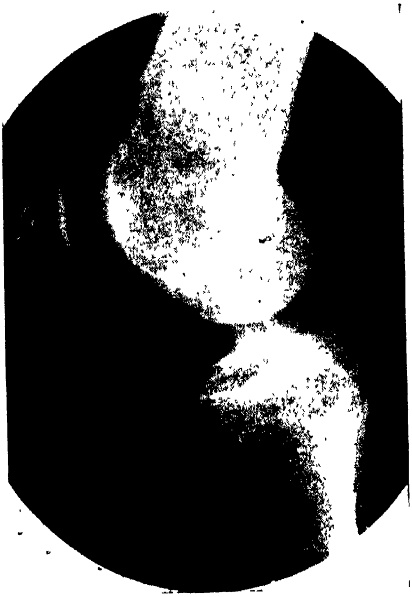
In the resulting skiagram the patella should stand just clear of the anterior surface of the femur, and the joint should show a clear space except where the tibial spines extend into the intercondylar notch of the femur. The sesamoid bone, in the outer head of the gastrocnemius, is often seen in adults, and should not be diagnosed as a loose body in the joint.

(*c*) *The ankle joint* is also examined in two planes, and presents no special features except that in the anteroposterior view the foot should be inverted slightly so as to separate completely the lower ends of the tibia and fibula, the central ray being directed through the midpoint of a line joining the two malleoli with the foot plantar flexed. In the lateral view the limb is externally

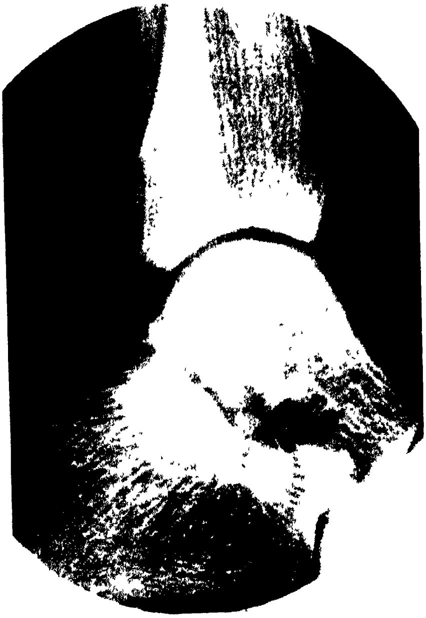
PLATE X.



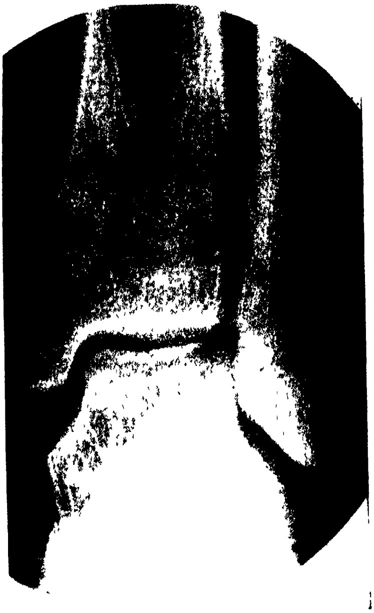
Normal knee joint.



Normal knee joint.



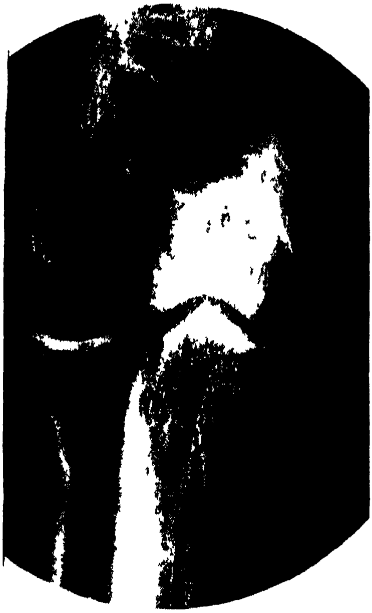
Normal ankle joint.



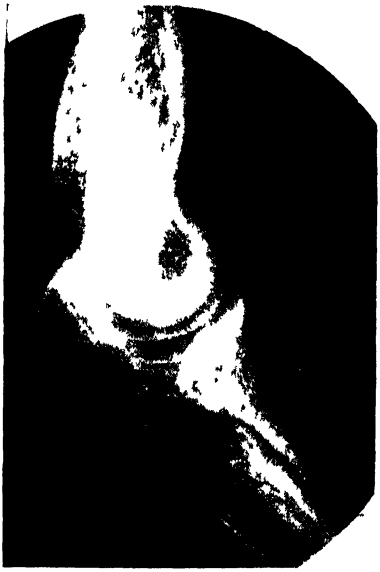
Normal ankle joint

To face p 742.

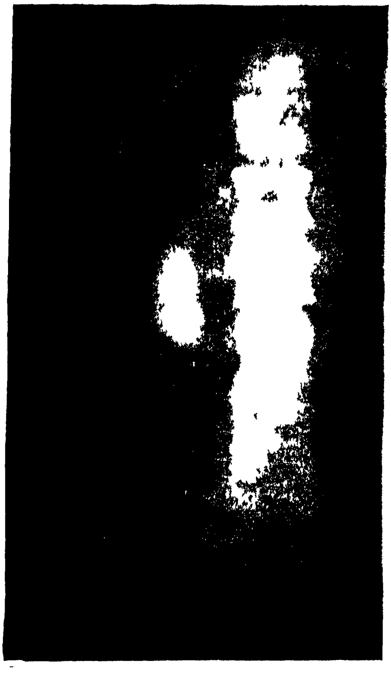
PLATE XI.



Normal elbow joint



Normal elbow joint.



Normal gall-bladder, showing the shadow cast by the dye.

Pyelogram of a normal kidney.

rotated, the outer side of the foot lying on the cassette or unscreened film, the plane of the leg being parallel to that of the film. The tarsal joints are examined with the foot lying flat, in the normal way on the film, and the line of the central ray passing through the midpoint of a line joining the tubercle of the scaphoid and the tip of the base of the fifth metatarsal.

The Pelvis, as a whole, is examined on one large film, using the Potter-Bucky diaphragm, and if need be, as in the case of fractures with displacements, stereoscopically. It is placed so that the central ray passes through the midpoint of a line joining the hip joints, and the whole structure can be shown, except in very large patients, on a film of 15 inches by 12 inches. Special portions of the pelvis may be examined as required, and the Potter-Bucky technique is used in all cases.

The Ribs and Sternum remain for consideration. In the case of the ribs it is usual to include only those which are suspected of injury or disease, but sometimes it is preferable to take in the whole bony structure of the thorax. In the examination for fractures antero-posterior or postero-anterior views will be required, depending on the site of the injury. If this is in or near the axillary line one or more oblique views are necessary so that a complete view of the whole of the rib is obtained. Where bony displacements may have occurred, or to locate some dense intrathoracic shadow, stereoscopic films are required. The views are taken on large films of not less than 15 inches by 12 inches, and the tube movement must be made longitudinally in the line of the spine, or the ribs will fail to give a good stereoscopic view, owing to the tube movement being parallel to their long axis. When reading the films so taken in the stereoscope they must be laid, as it were, on their side, so that the movement corresponds to the line of the eyes. Although somewhat awkward at first, the eye soon becomes accustomed to this view.

The best method of examination is by an oblique view, arranging the patient's chest in the left oblique position, with the left chest in contact with the cassette and the right chest raised. The central ray passes just internal to the vertebral border of the right scapula. A lateral view should be included. This is best taken with the patient seated erect with the shoulders well back. The film is placed at right angles to the broad plane of the sternum and the central ray should pass through the sternal angle.

The *radiographic examination of the muscular and tendinous structures* of the body is not of much value, except where some gross abnormality exists Such conditions as *myositis ossificans* and *surgical emphysema* are shown quite clearly, and several cases of *gas gangrene* have shown with great clarity the gas dividing up the muscle layers. *Displaced semilunar cartilages* in the knee joint cannot be seen until some thickening or early ossification has taken place, or when in the lateral view a few fibres of the coronary ligament in front become detached and form little osseous nodules.

Abscesses arising from local bone or other infections may show as dense areas and may displace organs, but it is seldom possible to arrive at an accurate diagnosis till they have been in existence for a long period and show signs of calcification.

A collection of blood in the tissues such as a *hæmatoma,* shows quite a dense shadow.

EXAMINATION OF THE URINARY TRACT

In examining the urinary tract both solid and hollow viscera have to be dealt with. For radiodiagnostic purposes the tract may be divided into three parts: the kidneys and upper halves of the ureters, the lower halves of the ureters and bladder, and lastly, of less importance with this technique, the penile urethra.

It is obvious that the negative must cover the whole tract, or else two negatives made, which overlap, so that no part is missed.

The kidneys, by the fact of their solid structure and the perinephric layer of fat, usually may be clearly outlined on a negative as they cast a heavier shadow than the surrounding tissue, and a satisfactory negative of this organ should, in addition, show clearly the border of the psoas muscle; also the lumbar vertebræ, the last two ribs and the iliac crest.

The centering of the incident ray should be over the tip of the ninth costal cartilage for each kidney and the ray be directed vertically downwards. For the bladder the central ray should pass through a point midway between the umbilicus and the symphysis pubis and be directed downwards at an angle of approximately 20 degrees from the vertical. In all cases the Potter-Bucky diaphragm and double screen technique should be used, and a tube of medium penetration should be employed in the overhead position. The apparatus supplying the current should be of such power that exposures in excess of three seconds are unnecessary. Since the kidneys move during respiration the exposure must be made with the patient holding the breath.

Of great importance is the correct preparation of the patient. Many are sent direct from the out-patient department for examination, and such findings as may result, except in cases of large and obvious calculi, are of comparatively little value. Where possible the patient should be admitted to a ward fifty-six hours or more beforehand, so that proper preparation may be carried out under trained and responsible supervision.

The method found best in effect is to give mild laxatives for three days previous to the examination till the bowel is cleared of all fæcal matter. Enemata should never be given within twenty-four hours of the examination, or the large gut will invariably be found markedly dilated with gas, which entirely obliterates the kidney shadow.

When possible enemata should be avoided altogether. Metallic salts in pill or tabloid form are always to be avoided, as not infrequently they may appear unaltered in a skiagram, lying as a dense opacity in the gut, where they have been mistaken for calculi in the ureters.

In all cases at the first examination the whole tract should be radiographed. Where any suspicious shadows are seen, subsequent examinations must be made after further preparations to confirm their presence or otherwise, and various methods are here made use of.

The Kidneys. In the case of the kidneys three methods are in common use:—

(*a*) The first depends for its accuracy on a lateral view through the body. It is easy to see that very small calculi of the size of a pin's head cannot be visualised through such bulk of tissue, but in the case of larger shadows the lateral view is of great help by determining whether the shadow lies in front of or behind the anterior border of the bodies of the vertebræ. Where it is behind, a calculus is indicated; where in front, calcified mesenteric glands or, on the right side, a gall-stone may be suspected.

(*b*) A second method, especially useful in the case of small shadows, is to take two skiagrams with tube, patient and film in the same relative position both times. Make the first exposure in full inspiration and the second in full expiration. Note the difference in position of the kidney shadow and see by careful measurement if the shadow has retained its exact relationship to the renal outline.

(*c*) The third method is **pyelography,** which may be divided into ascending and descending or excretion urography. (*a*) In *ascending pyelography* the method depends on the passage up the ureters of long *specially made catheters* to the pelvis of the organ. These catheters must be sufficiently opaque to show up clearly, and when in position a stereoscopic pair of radiograms is taken which gives the relation of the suspected stone to the tip of the catheter. After this has been done the surgeon may inject from 5 to 8 c.c. of an opaque solution up the catheters into the pelvis of the kidney, mildly distending it, and further films will show if the shadow has merged into the opaque fluid or not. Such a picture is called a **pyelogram,** and the passage of the catheters invariably must be carried out by the surgeon with full aseptic precautions. General anæsthetics for the operation are strongly to be deprecated, as in the first place, if anæsthetised, the patient cannot hold his breath, and, in the second, the pain felt by the patient during distension of the pelvis is the only safe and rational way of filling it completely without the risk of overdistension and damage to the organ, which may be serious. The solution most commonly used for the purpose is a 20 per cent. solution of sodium bromide, but sodium iodide in 13 per cent. strength casts a heavier shadow and appears to have no injurious effect. (*b*) Descending or intravenous pyelography has now become a routine method of investigation. The original compounds consisted of uroselectan B and perabrodil, but these have been followed by other iodine preparations which when injected intravenously are rapidly secreted by the glomeruli of the kidneys producing an opaque urine. Thus excretion urography demonstrates the comparative excretory powers of the kidneys, and subsequently by filling the calyces, pelves, ureters and bladder establishes a complete outline of the urinary tract. Skiagraphs are made at intervals of five to thirty minutes, but in some cases of delayed excretion it may be necessary to continue for two or three hours. By this method a small calculus in the kidney may be obscured by the opaque urine, but in the ureter it is more easily demonstrated either because it causes dilatation above or by filling the ureter surrounding it. Filling defects in the calyces and pelvis will be evidence of renal disease. It is also used to demonstrate the presence of ectopic and horseshoe kidneys. Although this method gives in most cases only additional information to that obtained from ascending pyelography, yet there are some cases in which the descending method has to be used alone. Such cases are those where the small size of the meatus in a child or a urethral stricture or prostatic hypertrophy may prevent the passage of the cystoscope. When the bladder is filled with blood and the ureteric orifice cannot be found or ureteric kinking prevents the catheter from going sufficiently high up, excretion urography often gives the desired information. Again, excretion urography must be the method of choice in cases of infection of the urethra or bladder, where pyelography by catheterisation might be thought likely to spread infection up to the kidneys. The preparations used are non-toxic in the prescribed dosage, but if injected too rapidly may cause a fall of blood pressure and vomiting. They are not well excreted by patients with damaged kidneys, and the injection may precipitate uræmia in patients on the brink of it. This method should be avoided in any patient known to have an idiosyncrasy for iodine. In addition to the preparation already described it is essential to limit the fluid intake for twenty-four hours and to reduce it to a minimum for twelve hours prior to the injection, thereby ensuring a concentrated urine.

The Ureters come next under consideration. They pass from the pelvis of the kidney downwards to the sacroiliac joints, and passing towards the midline again to the papillæ, where they empty into the urinary bladder and where calculi most often lodge. Their point of entry can be located with sufficient accuracy by taking two points, 1·5 cm. either side of the midpoint of the line joining the ischial tuberosities. The ureters themselves are not opaque to the rays and are of interest in so far as they may have calculi impacted in them on their way down to the bladder. Where shadows do occur in the line of the ureters a lateral view may help in the upper half, but *the passage of the opaque catheter or ureteric bougie* with stereoscopic skiagrams is far more satisfactory and usually clears up the diagnosis. With an impacted stone the bougie sometimes cannot be passed up to its proper distance and the stereoscopic skiagrams will reveal the end abutting on the suspected shadow. In other cases the catheter will go right up past the calculus and its shadow will then be seen in contact with that of the stone. If the ureter is very dilated, it may not be in actual contact. In intravenous pyelography it is necessary to compress the lower end of the ureters to obtain good visualisation.

The Urinary Bladder. The radiographic examination of this organ is of great importance, and it must be viewed from two points. The bladder may contain bodies opaque to the rays, such as foreign bodies or calculi; it may be the seat of papillomata on which opaque deposits of phosphates occur, or it may have diverticula protruding from its walls, which can be demonstrated by *cystograms* taken of the organ dilated by opaque solutions in the same way as the pelvis of the kidney, and radiographed stereoscopically and laterally. The *prostate gland* situated at its base is in late life often seen to contain multiple small shadows indicating calculi lying within the crypts of the gland.

Foreign bodies are rare, and when present are found almost invariably in the female, whose short urethra allows the passage of some types of foreign body easily. Among such have been found clay pipe stems, pencils and pencil cases, hair pins, and in one case a thimble. Calculi are of frequent occurrence, and may be single and loose in the bladder or multiple and lodged in small diverticula in the bladder wall.

The Penile Urethra has been studied recently radiographically by means of a technique employing an oily opaque substance known as lipiodol. This fluid is injected under gentle pressure through the urethra and skiagrams are taken during the flow. False passages and strictures were demonstrated, and the method is of undoubted value in the treatment of post-gonorrhœal conditions and some prostatic enlargements. The lipiodol actually was emulsified with saline for the purpose.

THE BILIARY TRACT

The biliary tract has of late years come more to the front from a radiodiagnostic point of view owing to the better technique now available, but it is still very far from perfectly satisfactory. Owing to its composition, the average gall-stone is frequently incapable of throwing any greater density of shadow than the surrounding tissues, i.e., in the case of the pure cholesterin stone. In more advanced age a thin layer of calcium salts is sometimes deposited upon the stone, and by the shadow of this calcium layer appearing in the form of a ring about each stone, the diagnosis may be made certain. At the same time a large number of gall-stones suspected clinically cannot be shown up by any direct method, and other means must be utilised in the endeavour to assist in the diagnosis. These methods are three in number:—

1. First by removing all tissues from the neighbourhood of the organ by the *injection of sterilised air or carbon dioxide into the peritoneal cavity.* This displaces the surrounding abdominal contents and a skiagram may be taken showing the organs separated by layers of gas and the gall-bladder lying more or less free in the cavity. In this country it has practically dropped out of use, as the method is decidedly risky from infection, possible air-embolism during puncture, and from undue traction on the heart through the liver falling out of place and dragging down the diaphragm with it. It also causes much discomfort to the patient, which could otherwise be avoided.

2. The second method is *by examining the surrounding hollow viscera,* the antrum of the stomach and first part of the duodenum or duodenal cap by filling them with opaque food, as will be described later. A large or chronically inflamed gall-bladder has a definite reaction on these organs, and may tend to draw them out of place and more into the hypochondrium than normally, or if simply enlarged it may cause its impress upon them to be plainly visible as a filling defect.

3. The third and more recent method is that invented by Graham, in which a chemical substance is introduced into the body, which has a selective action on the liver and is excreted by the liver into the bile, at the same time being definitely opaque to the rays. The two salts found to have this action are *sodium tetrabromphenolphthalein* and *sodium tetraiodphenolphthalein,* the latter of the two giving a somewhat denser shadow than the former, though it is stated to be rather the more toxic. Two methods of administering the salts have been used successfully. In the first the sterilised solution of the dye is injected intravenously, the patient being previously placed upon a light, fat-free diet, and starved completely of all but fluids from the time of the injection. The skiagrams are taken at intervals of four, eight, twelve and twenty-four hours after the injection, and great care must be exercised during the injection that no drop of the solution escapes from vein or needle into the subcutaneous tissue, or an intense inflammatory reaction will be set up which may lead to necrosis.

The later and easier method is to give the iodine compound by the mouth. The modern preparations of sodium tetraiodphenolphthalein are well tolerated. In some instances nausea occurs or excessive bowel action. This is obviated by the administration of an opiate, as a routine, one hour after taking the dye. Before giving the dye by the mouth, the patient has, as in all similar examinations, thorough preparation up to twenty-four hours beforehand, and is given a light, fat-free diet. A final meal is then given of steamed white fish followed immediately by the dye. The skiagrams are taken twelve hours subsequently, at which time the normal gall-bladder should be well outlined. At this stage filling defects due to the presence of non-opaque stones are apparent. They produce a translucent shadow in the opaque medium. Similarly, opaque stones are confirmed and their position demonstrated. A fatty meal should be given followed by further examination at one or two hour intervals.

In the normal the gall-bladder empties almost completely or totally. In the presence of stones or disease contraction is incomplete or no contraction occurs. In a small percentage of cases examined by this method no secretion of the dye occurs in the gall-bladder. In some instances the dye has not been absorbed as evidenced by its presence in the colon. In others, although absorbed, it is not secreted in sufficient concentration to render the bile opaque. In the absence of a filled gall-bladder the examination must be regarded as inconclusive.

From the foregoing it will be seen that the gall-bladder presents many difficulties in arriving at a helpful conclusion, but it is usually worth while trying some of the methods in doubtful cases, as not infrequently a definitely negative result may be obtained, which will save the patient from an exploratory laparotomy.

THE ALIMENTARY TRACT

For purposes of examination the alimentary tract is subdivided into the mouth from the dental standpoint, the œsophagus, the stomach, the duodenum, the small intestine, with its two subdivisions of jejunum and ileum, and the large intestine. This last is again subdivided into cæcum and appendix, ascending colon, hepatic flexure, transverse colon, splenic flexure, descending colon, sigmoid or pelvic colon and rectum.

The Examination of the Teeth is carried out on a number of small, specially prepared films, and is described on page 739. A film will be required for each molar region, each bicuspid region, and each incisor region, i.e., five for each jaw. When dried they should be mounted to present the appearance seen on looking into the mouth from the dental surgeon's point of view. Much important pathological change can be seen in good films, but wherever a tooth is doubtful it should be radiographed again from two or more different angles.

Root infections should be noted, alterations in structure or density of the bone and periodontal membrane and lamella. In the upper jaw never mistake a low antrum for an apical abscess. When in doubt look for a break in the continuity of the periodontal lamella.

The remainder of the tract cannot be examined by the direct method, as the hollow viscera cannot for lack of density be visualised. An indirect method of simple technique has been devised. Food is given to the patient, acting as a vehicle for inert salts of some heavy metal which, in a finely divided state, makes an opaque mass of a fluid consistency. The metallic salts most commonly used are those of bismuth and barium. Bismuth carbonate, at one time very extensively used, has now largely given way to the insoluble sulphate of barium. The latter is equally dense, safe, and far less expensive, but before preparation it must be chemically tested for the presence of soluble salts, which are highly poisonous.

Many forms of meal are made up, almost all of which are good, but a simple mixture which is not unpalatable and of a correct consistency is that containing Allenbury's Invalid Diet, half an ounce of starch, and has four ounces of barium sulphate stirred into it while heating, checking when the required consistency is obtained.

The examination of the hollow viscera is carried out by the full use of the fluoroscopic screen, together with good radiograms, which must be taken by short exposures of not more than two-fifths of a second where possible. In obese patients this is difficult and sometimes impossible, but in normal individuals such speed does away with the danger of movement of the viscus by peristalsis and of the consequent blurring of outlines, with loss of detail sometimes of the greatest importance ; it should present no difficulties.

The Œsophagus naturally is the first part to come under notice. The patient is placed standing between the tube and fluorescent screen facing the operator, who proceeds to screen the chest in general. Having noted the presence or absence of gross abnormalities, the operator turns the patient into the right oblique position, watching on the screen until the mediastinal space is a clear area between the heart shadow and the anterior border of the vertebral column. To make the position more clear the patient is turned to his "half left." Whilst screening small quantities of thick barium paste are given and the bolus watched through its passage. If a pouch is present this fills first and thereafter the opaque material passes on, perhaps with difficulty. A foreign body may cause obstruction or establish its presence by causing a spasm or splitting up the bolus. Obstruction due to a neoplasm may be complete or produce a narrowed lumen or an irregular filling defect.

Other causes of obstruction such as the stenosis due to the swallowing of caustic material and spasm caused by an ulcer may be recognised; and cardiospasm is usually established by a marked dilatation of the œsophagus. The routine examination is made in the erect position, but in some instances the Trendelenburg position is helpful in establishing the extent of neoplastic invasion and the position of the lower end of the œsophagus.

Skiagrams are made for confirmation and purposes of record.

The Stomach is examined during the act of filling and the food is seen to pass through the cardiac orifice in a well-formed stream filling up the mid-cardiac end and gravitating to the dependent part of the great curvature.

When filling is complete, as should be the case with from 10 to 12 ounces of the semi-liquid food, the operator proceeds to examine the greater and lesser curvatures and the anterior and posterior walls by turning the patient about under the screen and noting any abnormalities. The true cardiac end, if suspected, may be seen best by placing the patient prone and turned slightly to the left to fill that end of the stomach. Following this the pyloric end is examined and the passage of food through the pylorus into the duodenum. Here it is necessary to manipulate the stomach with the gloved hands and to try to pump food out and trap it in the duodenum. Ulcers are often demonstrated by mushroom-like excrescences in the shadow and growths by "filling defects."

The Duodenum itself consists of three parts, the first part or cap and the the second and third parts, the last of which terminates in the duodenojejunal flexure lying behind the body of the stomach. Radiologically *the cap* is of great importance, as it is the most common site of ulceration, the presence of which is suspected by, inter alia, the distortion of the normal outline, which is roughly that of an edible chestnut. The second part usually passes the food very rapidly on, and all that can be seen are a few scattered particles of food. The third part may contain a small quantity of food normally for short periods, and is recognised by its semilunar outline with a number of small indentations where the organ lies across the first part of the mesenteric vessels.

The Small Intestine is seldom visualised accurately, as the passage of food is rapid and fragmentary. On the screen small masses of food can be seen passing round the coils of gut, but until the lower end of the ileum is reached, there is constant movement. In this latter situation a definite slowing down is seen and in the normal subject the head of the meal begins to pass through the ileocæcal valve in from two and a half to three and a half hours, and the entire meal will be seen to have passed completely into the large intestine in from six to eight hours. Its passage onward through **the large intestine** is a very variable quantity, and the head of the meal may be said to reach the rectum normally in from twenty-four to thirty-six hours, when fragments will be seen throughout its entire length. The value of examination of the large bowel by the orally administered meal is often unsatisfactory as the barium becomes scattered irregularly through it at the twenty-four and forty-eight hour intervals or is passed during such intervals when it might be informative. Nevertheless in the course of a meal it may be useful where the colon is under suspicion to follow the passage of the food to the rectum, but, according to the tone and position of the gut, this examination may extend over long periods of seventy hours and upwards.

The Opaque Enema. The examination of the large intestine is best carried out by the injection, under a small head of pressure, of a quantity of opaque fluid. The enema method allows of the colon being outlined in all areas and of its examination by palpation under the screen. In addition as the fluid is run in, each portion of the gut can be separated and inspected from different angles.

The preparation of the patient is of the utmost importance. Unless the colon is completely empty, retention of the enema is difficult and the presence of fæces may interfere with the normal passage of the fluid and cause errors of interpretation. It is therefore important to clear the bowel by an aperient and lavage some hours before the examination. Food intake should be restricted, but complete fasting is not necessary. The opaque fluid used is a suspension of barium sulphate in water containing a small quantity of mucilage of tragacanth to assist in suspension. It must be definitely fluid and be entirely free from lumpiness, or the enema tube will be blocked up. The administration takes place from a douch can supported about 3 feet above the patient, and connected to an ordinary nozzle by a rubber tube, in which is inserted a Higginson's syringe from which the valves have been removed. This enables manual pressure to be exerted by pinching the tube behind the bulb and squeezing the bulb. It is rarely necessary, however, as the head of fluid gives ample pressure by itself. The nozzle is inserted into the rectum and the tap turned on, the patient lying supine with the tube below and the fluorescent screen above.

During filling, the flow of the head of the column of fluid is watched by intermittent screening, and where blocks occur light massage is resorted to to relax spasm of the gut, which may be misleading.

Probably the most common lesion met with is *carcinoma of the colon.* Its most common sites are the lower sigmoid, the junction of the descending colon with the sigmoid, the cæcum and the flexures, hepatic and splenic. In the sigmoid there is usually a small area of apparent narrowing which is normal, and should give rise to no doubt owing to complete lack of obstruction. In the case of malignant strictures there is wide dilatation of the gut below when they are advanced, with more or less complete obstruction to the flow of fluid. In the earlier stages they are seen as filling defects in the bowel outline. When the gut has been filled as far as practicable a skiagram is taken on a large film to include as far as possible the entire column of fluid, and if any particular point is outstanding a smaller film to cover that area is taken in addition. Where much dilatation has occurred and there is masking of a particular point by folds of gut, small films of doubtful areas may be taken during filling and after partial evacuation. Other conditions commonly demonstrated are those of diverticulitis, chronic colitis and the normal or diseased appendix.

Inability to fill the colon beyond the sigmoid constantly occurs owing to a lax sphincter or the inability of the patient to retain an enema. Again complete obstruction in the lower colon caused by an acute diverticulitis cannot be differentiated from that caused by a neoplasm.

In *diverticulitis* where there is much local inflammatory thickening, a filling defect is produced which may be similar to a neoplastic invasion. It has, however, a more jagged and irregular appearance, whilst at its margins small diverticula usually project. In *chronic colitis* the normal pouching and bending of the gut is destroyed, and it becomes a series of nearly straight-sided patent tubes joining the various flexures, from the destruction of the muscle wall and inflammatory infiltration.

The *appendix* is examined either by an opaque meal or an enema. In the former method it is filled in about 50 per cent. of cases at the six to twenty-four hour intervals. The fact that it does not fill must not be regarded as diagnostic of disease. It is best examined under the screen with the patient in the supine position. By palpation with the gloved hand the cæcum may be moved to allow a better visualisation and skiagrams can subsequently be made. The examination may disclose :—

1. Abnormal filling with a small or wide lumen.
2. Stenosis or kinking.
3. Definite fixation ; sometimes in an abnormal position.
4. Retention when the cæcum is empty.
5. Defined localised tenderness on palpation.

THE THORAX

The thorax is more concerned from a radiological standpoint, perhaps, with inflammatory or other lesions and as an air-containing space, it is very readily examined on account of its ease of penetration. With the advance of thoracic surgery and the continued expansion of the treatment of pulmonary lesions by artificial pneumothorax the aid of radioscopy and radiography becomes more essential.

By screen examination the physician can determine the degree of collapse of a lung and the amount of fluid present and this enables him to decide on fluid withdrawal and air replacement. The skiagrams will demonstrate pleural adhesions and under fluoroscopic control these may be severed.

With the advent of the *tomograph* predetermined depths of the body may be skiagraphed to the exclusion of the other structures. It is particularly applicable to the demonstration of pulmonary cavities and foreign bodies.

The technique employed is that of the fluorescent screen, combined with films taken by using the double screen method and with extremely short exposures not exceeding one-twentieth of a second, as this gives a sharp heart outline. In the first place, let it be stated that there is no radiological difference between serous fluid and pus. Such a fluid, when present, collects usually in the bases of the pleural sacs. The local mechanical action must be understood. The lung in contact with the fluid is partially collapsed and the shadow of the heart which normally occupies the centre space will be swung away to a greater or less extent from the site of the lesion. The heart is normally maintained in its central position by the equal elasticity of the two lungs. If for any reason one lung occupies less space than normal, then so long as practically no consolidation occurs in it, the balance of elasticity will be maintained throughout both lungs, causing the heart to swing somewhat away from the affected side. Fluid, when present, gravitates to the bases of the lungs and is seen as a sickle-shaped opacity extending upwards on the lateral chest wall. Where consolidation takes place, the lung itself becomes solid and its elasticity is to some extent destroyed, so that the position of the heart does not materially alter, though in full inspiration it may appear to move slightly towards the affected side, and in full expiration slightly away from it. In cases where air escapes into the fluid, the level of that fluid will be marked clearly and movements of ripples on its surface are seen. The examination is carried out, wherever possible, first with the fluorescent screen, with the patient either standing or sitting in the upright position. Skiagrams are taken after the screening has been carried out.

The *mediastinum* is of great importance, and is examined as in the foregoing paragraph, except that much stress must be laid on information gained from the views obtained when the patient is turned obliquely, especially to his " half left." The posterior mediastinum is seen normally as a clear space lying between the posterior border of the heart shadow and that of the anterior border of the vertebral bodies. The anterior mediastinum, of less importance, lies between the sternum in front and the anterior border of the heart shadow. In the posterior mediastinum the structures most commonly affected are the lymphatic glands, including those at the lung roots, and the œsophagus, which is frequently the seat of malignant disease and has been dealt with already.

Where gland affections are present the clear space is to a greater or less extent obliterated and irregular shadows extend beyond the heart borders. The obliteration of the anterior mediastinum is more commonly seen in the case of aortic aneurysm.

The *diaphragm*, with its two rounded cupolæ, always must be carefully examined as to its outline, position and range of movement, and a condition of great interest, though rarely met with, is herniation of the abdominal contents through the diaphragm, usually on the left side, into the thorax. In such a case the normal diaphragmatic outline is lost and irregular shadows of gas-filled intestine replace that of the normal lung. Administration of an opaque meal will usually remove any doubt about the condition.

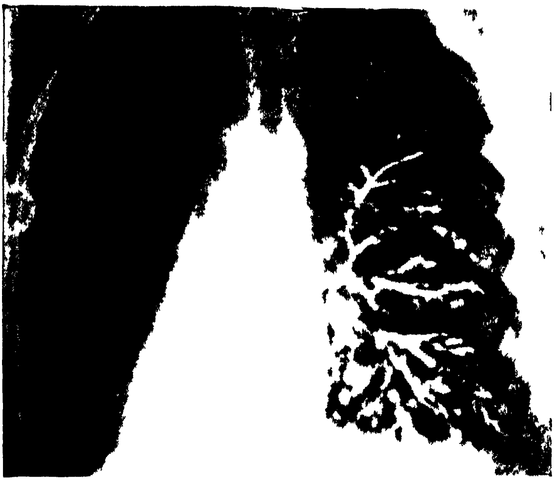
The diaphragm is sometimes an accurate indicator of a subphrenic abscess, when it is seen to be elevated above its normal by pressure and fixed by muscular spasm owing to its inflammatory involvement from below.

THE BRAIN

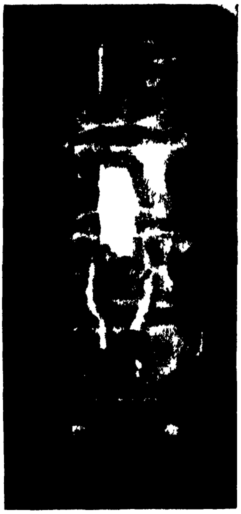
Much of the technique of examination of the brain centres about skiagrams of the skull, as the brain tissue is in itself insufficiently dense to cast any shadow when lying within its osseous case. Many morbid conditions of the brain also are caused by pressure of tumours or other conditions of the skull itself and its other contents. It is necessary, therefore, to take a view of the skull so as to show its inner contour, and this is best done by stereoscopy.

In all cases the double-screen technique is used, and where patients are not restless the Bucky diaphragm is made use of in addition. The most satisfactory views are taken laterally, with slight modifications of direction of the central ray towards areas which lie under suspicion. In some cases stereoscopic postero-anterior views may be of the greatest help.

In *fractures of the vault* the fissured type is most commonly seen, and it and the various types of depressed fracture present no special difficulties.

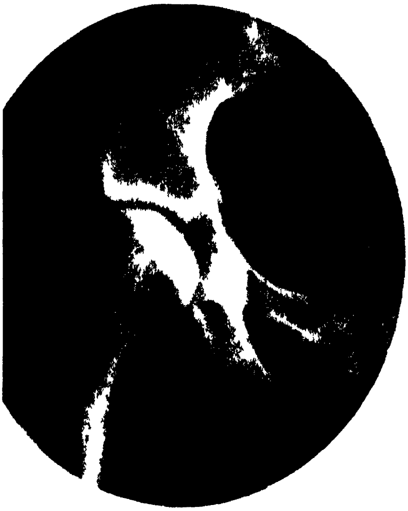


Injection of lipiodol into the normal right bronchial tree



Lipiodol lying at the top limit of a tumour in the spinal canal

Lipiodol lying in the spinal canal



Normal hip joint.

Fractures of the base are common, but unfortunately, unless well marked, they are difficult to see, owing to the complex structure of that part of the skull. Hence it may be pointed out that negative X-ray findings in suspected basal fractures are of little value.

Tumours of the skull, such as osteoma, sarcoma, and general thickenings, as in osteitis deformans and syphilis, are obvious in a clear skiagram, though the interpretation of the different types is often far from easy.

Tumours of the meninges are seldom, if ever, seen unless they cause local bone changes, when they are seldom recognised as being meningeal in origin.

Tumours of the substance of the brain itself are of two types radiologically—the visible type, which is rare, and the gliomatous type, having the same density to the rays as the surrounding tissue. To the former type belong the psammomata or sand tumours, rarely seen and not to be mixed up with the pineal body, which is visible as a small calcified body of about 2 to 3 mm. in diameter lying centrally and present in many normal adults. Small sandlike tumours are occasionally seen in the meninges dipping down in the median sulcus between the two hemispheres.

Of the invisible type of tumour there are two signs where the condition has persisted for some time: (*a*) The first is abnormal widening of the sutures of the skull and will only be found in the long-standing case. (*b*) The second is attained by puncturing the skull and passing a hollow needle into the ventricle of one side (**Ventriculography**). A quantity of cerebrospinal fluid is withdrawn and sterilised air is passed into the cavity of the ventricle; the needle is withdrawn and the wound closed. The skiagrams are then taken, and marked distortion of the ventricle of the affected side is seen. In cases where the tumour is centrally situated there is often a blockage of the foramen of Monro, which normally allows the air to pass from one ventricle to the other. The air is usually absorbed in a few hours after injection (Vol. II., Ch. I.).

Encephalography is a method in which the cerebrospinal fluid is withdrawn at the third lumbar interspace by a special lumbar puncture needle and replaced by filtered air which passes into the ventricles and between the commissures of the brain. By stereoscopic skiagrams it is possible to demonstrate blocking of the foramina or interventricular tumours by the inequalities of the air shadows.

THE SPINAL CORD

In the radiographic examination of the spinal cord the same difficulties arise, and an excellent method has been devised by Sicard to locate points of pressure, whether by extra- or intra-thecal means. This consists in introducing into the cisterna magna, at the level of the foramen magnum of the skull, a small quantity of a heavy oily substance, named *lipiodol*, containing iodine. Some of the cerebrospinal fluid is first withdrawn and 1 c.c. of lipiodol is allowed to flow in to replace it. The properties of this fluid are that, being of greater specific gravity than the cerebrospinal fluid, it sinks down the cord so long as the patient is in a more or less upright position, and that, being extremely opaque to the rays, normal skiagrams of the spine will show its position. If there is any compression of the cord, the shadow will be found to be just above that point, while if none is present it sinks to the level of the second or third sacral segment. It is inert physiologically and appears to be absolutely innocuous. In cases of chronic meningitis it will pass down only in the form of droplets and will take many hours to collect in the sacrum, whereas in the normal state a very few minutes are sufficient for its passage.

A similar type of lipiodol has recently been devised which is lighter than the cerebrospinal fluid; it is introduced into the theca below any point of compression, such as a tumour, and floats up to it. The actual upper and lower limits of a tumour can be determined in this way. If preferred, to ascertain the lower limit of the tumour, the lipiodol may be injected below the point of compression of the cord and the patient placed with his head low and pelvis raised. The technique of its injection is outside the realm of this chapter, but it is sufficient to point out that it must be done by the surgeon with full aseptic precautions. (See Plate XII.)

It is not always possible to differentiate the tissue of origin of the tumour, but in some cases small meningeal tumours may be recognised by the shape taken up by the lipiodol. What is, however, certain are the upper and lower margins of the lesion, this giving the surgeon an exact indication for his operative procedure.

TREATMENT BY X-RAYS

Treatment by X-rays is broadly divided into two methods, first the use of a ray of comparatively medium penetration called *superficial treatment*, and secondly the use of rays of extreme penetration called *deep treatment*. The difference between the two is a matter of wavelength in the ray generated. As has been already pointed out, the shorter the wavelength, the higher is the penetration value. From every X-ray tube a more or less mixed beam of rays is obtained, and as the application of the long wavelength rays to the skin would rapidly produce inflammatory reactions in the superficial tissues, a method has been devised by which the less penetrating rays are absorbed before coming into contact with the skin of the patient. This is carried out by placing between the skin and the tube filters of aluminium of thickness varying according to the degree of penetration required; the thinner the filter, the larger is the quantity of low penetration rays allowed to pass to be absorbed in the superficial tissues. In giving treatment the distance from tube to skin is always a constant and the filter is placed halfway between these two. In certain skin lesions, where the reaction desired is to be superficial, no filter is used, and with the hot cathode types of tube giving a large number of rays only 0·25 mm. of aluminium need be used. The effect produced by the rays is in proportion to the quantity of rays which has been absorbed in the irradiated tissues.

(*a*) In the case of **superficial therapy** all doses are measured in certain ways, but the unit dose is that quantity of radiation given out by a tube at a constant voltage which will cause erythema, and is spoken of as the "erythema dose." Methods of measurement were carried out on chromoradiometers, which depend on the colour changes of certain chemicals in comparison to standard tints previously worked out to be equal to one "erythema dose." They were first made use of by Holznecht. The most commonly employed is that of Sabourand, who employed for the purpose small discs coated with barium platinocyanide, which under the ray influence changes from apple-green to a light brown shade, and is compared from time to time during a treatment with a standard tint equal to one "erythema dose."

As the discs or pastilles are not very sensitive, and to obtain a great enough colour change, they are placed halfway between the target of the tube and the skin, thus receiving four times the exposure of the latter, owing to the law of inverse squares governing the intensity of radiation at different distances from the source of origin. They must also be protected from heat rays, which may cause premature change, and should therefore be placed at about 2 cm. from the tube itself, which is always hot. The full Sabourand dose is spoken of as a B tint. Recently the iontoquantimeter because of its greater sensitivity has replaced the chromoradiometers.

The lesions most commonly treated by this superficial method are naturally those on or just below the skin. *Tinea, acne, lupus, rodent ulcer and warts* are among those successfully dealt with on the surface, while *superficial glands and new growths* often respond well to doses of 1, 1·5 or 2 B passed through 0·5 to 2 or 3 mm. of aluminium, according to the type of lesion and its estimated depth, the dose being measured after filtration and repeated as soon as is safe.

(*b*) In the so-called **deep therapy** the same underlying principle is at work, the chief differences being that a much higher voltage is used in a specially constructed tube, and the ray produced is much more highly penetrating in quality. As the lesion under treatment is deeply seated, it is necessary to try and produce in the tissues at a known depth the effect of an " erythema dose." The rays are very heavily filtered through 0·5 mm. of copper backed by 2 or 3 mm. of aluminium, and again by wood or boiler felt to absorb the secondary radiations of the metals of the filters. The central ray is directed through the part to be irradiated, and the maximum possible short of the " erythema dose " is given. It is, therefore, necessary to know not only the time of an " erythema dose," but also the difference between the surface dose and that obtained at various distances below the skin, or, in other words, the percentage of the skin dose which will penetrate to various depths. Having given the maximum dose allowable to the skin in one area, the tube is moved to another, the incident ray again directed to the point of the deep-seated lesion and the dose repeated. Thus the tube is moved from point to point over different skin areas, the line of the central ray always passing through the deep lesion until that lesion has received its correct dose.

In the early days of this method, as used by Wintz, of Erlangen, the full dose was given at one sitting, and this was known as the *intensive single or massive dose technique.* The effect of this was, however, to cause in the patient very profound general reactions; vomiting and pyrexia were marked, and in not a few cases death resulted. Under modern technique the dose is given over a number of days. There is much experimental evidence that most of the growths react better to irradiation applied over a long interval of time, and with this in view the intensive split-dose method has been evolved. The total dosage is distributed over fourteen to twenty-one days or longer, which allows the erythema dose to be increased by 200 to 250 per cent. The saturation method is used for the treatment of very rapidly growing tumours; it combines in a modified form the above two systems of treatment; the first dose given is just short of the erythema dose, and this is followed on each succeeding day by a 10 to 20 per cent. dose, so that the dose is kept up to saturation point for several days. The method of estimating the depth-dose at any given point within the body should be mentioned, though it is unnecessary here to go into great detail. It consists of the use of an instrument known as an iontoquantimeter, depending for its action on the ionising effect of rays on air, allowing it to become a conductor between the leaves of a charged electroscope. The greater the quantity of rays the more rapid will the fall of the electroscope be. The normal filters are placed over the tubes and the ray is directed through the ionisation chamber of the instrument, the rate of discharge being noted (of the electroscope). A "phantom" is then introduced between the tube and the ionisation chamber, which has the same powers of absorption as human tissue and of a thickness equal to the depth of the lesion. The rate of discharge is again read, and from these data the percentage of the surface dose received at the depth of the lesion is calculated. The phantom may consist of water, which absorbs only 5 per cent. less than the body, or a mixture of 20 per cent. beeswax and 80 per cent. paraffin. Sheets of this wax are used of 2 cm. thickness, and built up to the required depth.

As regards the action of rays on the different cells, those of the lowest physiological type are the most affected, and of these the ones undergoing active cell division are most susceptible. Lymphatic glands, ovaries, testicles, and other glands with internal secretions are especially sensitive; less so are the cells of the skin, mucous membranes, hair follicles, liver, kidneys, etc. The cells of the muscles and bones are the least sensitive and are unaffected by doses which would be sufficient to do great damage to lower grade cells.

The rationale of X-ray therapy, then, may be summed up briefly in the endeavour to kill pathological cells, which are all of a low grade, while the surrounding more highly specialised type feels little or no effect According to the strength of the dose absorbed by the tissues and their vulnerability, a temporary or permanent paralysis, atrophy or necrosis will follow.

By the close co-operation of deep X-ray therapy with surgery, Schmieden and Holdfelder, in Frankfurt, have been able to improve their cure of breast cancer up to 69 per cent. for five-year cases and 76 per cent. for three-year cases. This is almost 100 per cent. improvement on the five-year cures obtained by surgery alone at their clinic.

RADIUM TREATMENT

Radium is an element with an atomic weight of 226, belonging to the uranium series of alkaline earths, which possess the power of undergoing spontaneous disintegration, at the same time emitting radiations and giving rise to the formation of an atom of a lower atomic weight. Radium is a white metal which rapidly undergoes hydrolysis, so that it is usual to prepare the radium to be used in containers in the form of the insoluble sulphate, $RaSO_4$, which contains 70 per cent. of the radium element.

Radium salts emit three types of radiation: the alpha, the beta and the gamma rays, in the following proportions: 10,000 to 100 to 1 respectively. The penetrating powers of the three types of rays are, however, as 1 to 100 to 10,000; that is, although the gamma radiations are 10,000 times fewer than the alpha particles, they are 10,000 times more penetrating.

That the significance of the various types of rays emitted by radium may be understood, it is necessary to have some conception of their physical and biological properties and the part which they play in radium treatment.

The radio-active group of substances to which radium belongs undergo atomic disintegration at a fixed rate according to the following abridged table.

Member of Series.	Atomic Weight.	Period during which half the substance disintegrates.	Type of radiation emitted
Radium	226	1,700 years	α
Radon	222	3·85 days	α
Radium A	218	3 minutes	α
Radium B	214	26·8 minutes	β
Radium C	214	19·5 minutes	α, β, γ
Radium D	210	25 years	β
Radium E	210	5 days	β
Radium F	210	136 days	α
Radium G or lead . . .	206	Stable	Nil

It will be seen from the above table that radium disintegrates by passing through a number of stages into the inactive substance lead, and that whenever any of these stages is accompanied by the emission of an alpha particle the atomic weight falls by four. There is a great variation in the time taken for the substances to decay; for radium, 1,700 years is the half-time period, while in other members of the group this period is a matter of minutes or days. It will therefore be understood that in any specimen of radium all the other members of the group are present together in varying proportions. There will come a time, however, when these proportions will become constant, when the elements are said to be in *radio-active equilibrium*. All the members of this series are in the form of active deposit except **radon**, which is a gas. The gamma ray used in therapeutics comes from radium C, and not directly from the radium.

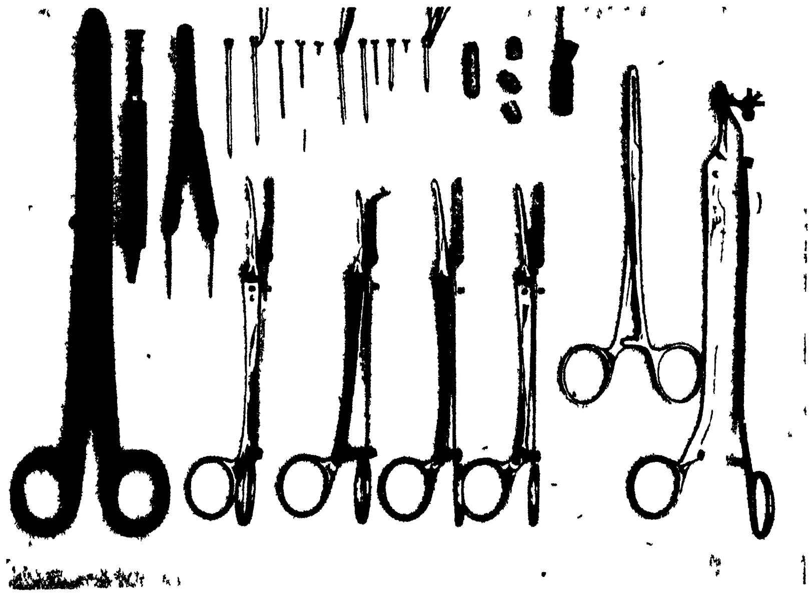
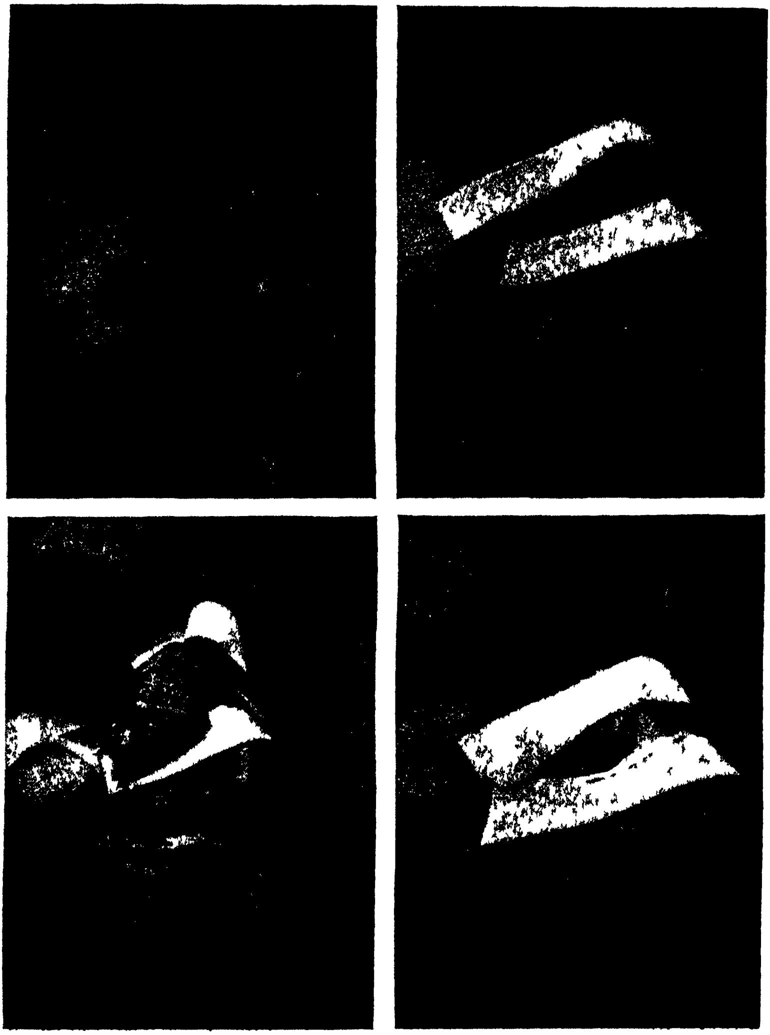


FIG. 379. Various types of needles and containers with introducing forceps.

The three types of rays emitted by the series are very different in their nature.

(*a*) The **alpha rays** are corpuscular, and consist of a stream of particles carrying a double positively charged helium atom moving with a velocity one-fifteenth that of light. From a therapeutic point of view, these rays are of no value, since they are so feebly penetrating that they are absorbed by a sheet of paper and cannot pass through the walls of the container. They may be slightly deflected by a strong magnetic field.



The lesion. Masking off the normal tissue.

Applying the plaque. The plaque fixed.

FIG. 380. Application of a plaque to a rodent ulcer.

(*b*) The **beta rays** are 100 times more penetrating than the alpha rays, and consist of rapidly moving electrons with a mass $\frac{1}{1850}$ of a hydrogen atom, and carry a single negative charge. The velocity of these particles is very approximately that of light. They can be divided into three groups: the *hard rays* are those capable of passing through 0·2 mm. of silver; the *medium* *rays* cannot pass through this silver screen, but will penetrate 0·2 mm. aluminium ; the *soft rays* are incapable of passing the aluminium filter.

In modern radium therapy the beta type of ray is generally eliminated by screenage, as their action is non-selective and caustic. They are still used, enclosed in flat applicators of Monel metal, a brass compound, in the treatment of rodent ulcers, keloids, hæmangiomata and warts.

(*c*) The **Gamma rays**, with a velocity similar to that of light, differ from the alpha and beta rays in being electro-magnetic vibrations of extreme shortness, varying between 0·02 to 0·001 Angstrom units, where 1A = one ten millionth of a millimetre. The penetrating power of the gamma ray is so great that the half-absorption thickness is 13·8 cm. of lead. They are unaffected by magnetic fields.

FIG. 381. Patient with an epithelioma of the angle of the mouth and secondary glands, holding plaque.

FIG. 382. Radium plaque in position.

The problem of radiation is further complicated by the generation of **secondary rays.** When the primary beta ray is stopped by an object it gives rise to a secondary gamma ray ; when the primary gamma ray is stopped it gives rise to a secondary beta ray, which in turn again, when stopped, gives rise to a secondary gamma ray, and so on. Every time a beta or gamma ray is stopped the ray produced is of a longer wavelength, and hence more easily absorbed.

In the early days of the therapeutic use of radium comparatively large quantities of the insoluble sulphate were used in tube-containers made of platinum of a wall-thickness of 0·25 mm. As much as 25 or 50 mg. were used and the dosage time was of short duration, being as a rule not longer than twelve hours. Another method advised and in use at the present time is the planting out of the salt in flat applicators with a known quantity per square centimetre. These preparations, known as plaques, are of various shapes and strengths and are used in the treatment of skin lesions. Beyond that their use is very limited.

The most modern technique makes use of hollow needles of platinum or some other suitable material containing the actual radium salt. In earlier types of this form a quantity of the sulphate was inserted which did not usually entirely fill the chamber, and thus the element distribution was apt to be irregular. Modern needles use a mixture of the radium sulphate precipitated in a diluent of barium sulphate, the whole needle being tightly packed with the mixture, which has a predetermined content of radium salt, and thus gives a known and accurate distribution through its entire active length. The measurement of such containers now is always made in terms of radium element, and is carried out by physical methods. Under modern conditions all such containers are made to have also a definite distribution of the element per centimetre active length, and one very largely and successfully used at the present time is that brought out by the French authorities of 0·66 mgm. per centimetre. The hard needle point and eye are naturally of solid metal, and therefore inactive; so a 1 mgm. needle is approximately 1·5 cm. long. From this it will be understood that needles of from 0·5 mg. to 2 or 3 mg. content will vary in size as to length, but throughout their *active* length the uniform element distribution is 0·66 mg. per centimetre. In accordance with this technique they have a uniform wall thickness of 0·5 mm., which cuts off 99·9 per cent. of beta rays, and at the same time filters out the softer gamma rays, reducing the total by 7 per cent.

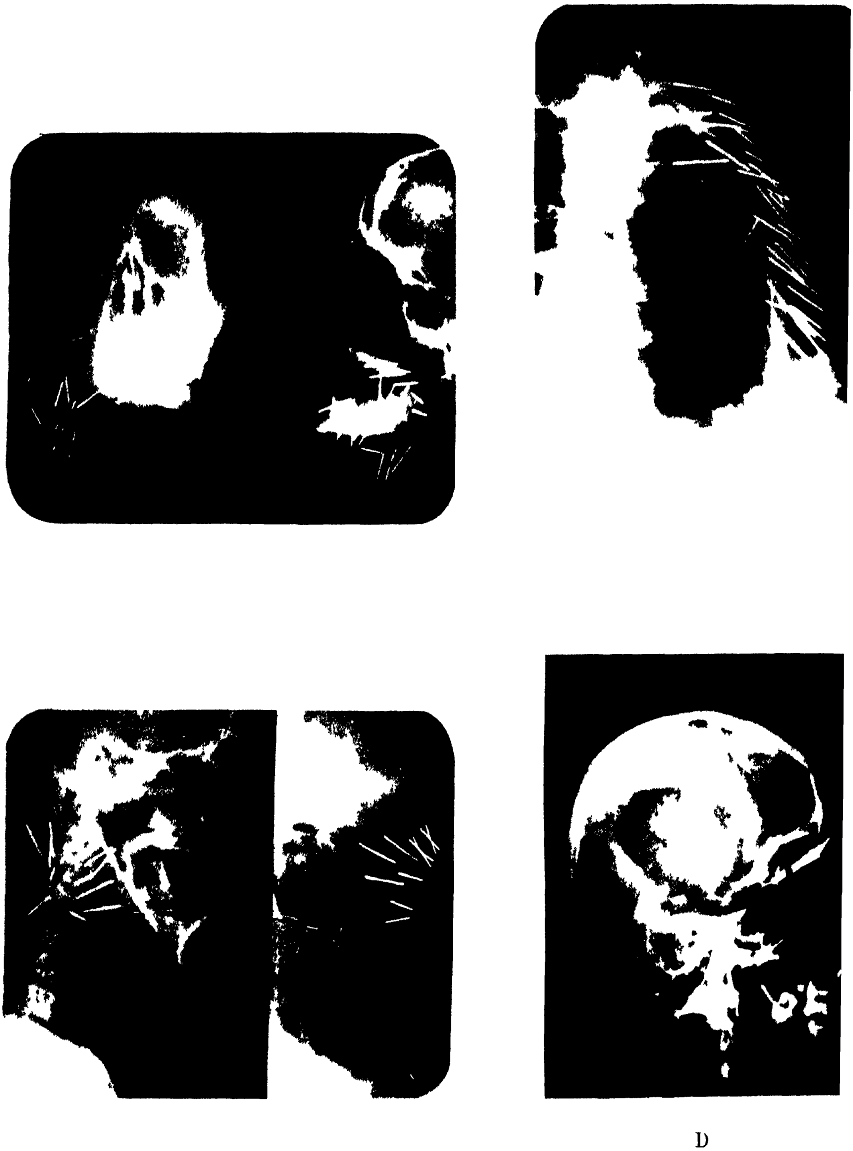
The reason for this careful method of distribution is the result of much research, which has proved that where a given quantity of element is not exceeded the needles can be left embedded in tissue without causing actual necrosis for very long periods of time provided that their relative distribution in the tissues is carefully made. They should be not nearer to one another than 2 cm. as, if the distance is less, the intervening tissue will receive a bulk of cross-fire radiation which it cannot support, and necrosis will ensue with all the deplorable sepsis which follows.

Dosage is often expressed in milligram-hours, which is arrived at by multiplying the number of milligrams of radium used by the number of hours for which it has been applied. It must be understood that, from a biological standpoint, the effect of applying 100 mg. for one hour is not the same as applying 1 mg. for 100 hours, and the milligram-hour is not an expression of the amount of radiation absorbed by the tissues.

In order that dosage may be specified accurately the details of the needles as to length, screenage and amount of radium used must be specified, the distance between each needle must be given, and the relations of the needles to the tumours.

The actual action of the radiation on tissues is obscure, but it is known that low grade cells, especially those in rapid mitoses, are most affected. Imagine, therefore, the state of such a cell under continual irradiation over a period of weeks. At first doses of 18 and 21 days were used in this method of application, but of late workers have found the best results were likely to be obtained in from 8 to 14 days. At the same time it must be recognised that there are many variants outside our present knowledge and control, and two tumours with every similarity in two different patients will react

PLATE XIII



X Ray photographs showing radium needles in position for radiation of—
A, Carcinoma of the Tongue B, Carcinoma of the Breast C, Malignant Glands of the Neck
D, Radon Seedlings in the Pituitary Fossa for Treatment of an Adenoma of the Pituitary

in exactly opposite ways, one shrinking and the other perhaps not responding at all favourably. Furthermore, it should be noted particularly that no matter how apparently favourable the initial local result may be, there is absolutely no guarantee of immunity from metastases.

From this use of the gamma radiation applied interstitially it was a natural step to try if large quantities could be projected into a growth from without the body and the necessary surgical technique, with its attendant risks, be avoided. The difficulties lay in skin reaction and in obtaining a sufficiently large quantity of the salt. In the former case where needles were embedded, the skin was not injured provided that the needle was not nearer to it than 2 mm., which indicated that any harm that had befallen was due to skin sensitivity, not to gamma but to soft metallic secondary radiation from the metal needles, for the skin remained untroubled by the gamma rays. Therefore a method was devised of making a support which would hold the needles at a fixed distance from the skin: *Columbia paste,* containing beeswax, paraffin wax and fine sawdust in certain proportions, is most commonly used. To keep the distance correct sheets are cast of 1·5 cm. uniform thickness; they are then softened to pliability by warmth, and moulded on to the part. On the outer side the needles are strapped at 2 cm. distance apart, and the whole is bound in place (Fig. 75, Vol. II.). It is not uncomfortable, and is daily removed for the patient's toilet for about an hour. Doses by this method may be as long as three weeks without causing serious reaction, and it is a fact that many tumours respond extraordinarily well, quite a number being reduced to an operable condition, and even almost disappearing with quantities of 60–70 mg. applied in this way over a comparatively large area.

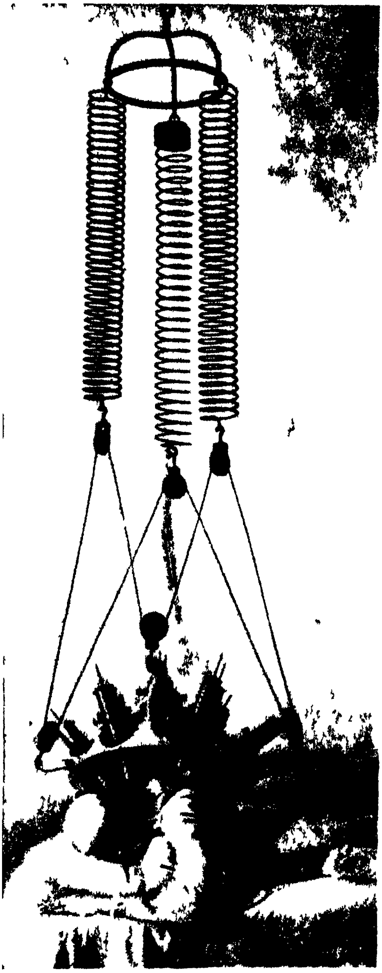


FIG. 383. Radium Bomb at the Radium Institute in Brussels Note the directional control of the container units.

The second external method is that of the radium "bomb" (Fig. 383). In this method a large quantity of the salt is collected, usually 3 to 10 grammes. It is subdivided into containers each of about 200 mg., in a tube-shaped "director" the open end of which can be aimed at any given spot. The total number of "directors" is then placed in a protected apparatus of which one, in use by the Radium Institute of Brussels, is illustrated. The whole is mounted over the patient in the manner illustrated, the streams of gamma radiation being concentrated as desired. One of the latest types is that erected by the Westminster Hospital in their Radium Annex in which two patients are treated at a time, one above and one below the bomb. The treatment is given in applications of 2 hours at a time, and repeated a number of times. The immediate result appears to be favourable on the tumour, but the question of metastases would seem to be quite as grave as ever. The result on the patient is that of considerable general disturbance of pyrexia, etc., and blood changes, believed to be of a temporary nature, are marked, the white count being greatly altered. There is a general leukopenia, and the lymphocytes completely disappear. Recovery from this appears to be reasonably rapid, but the workers, though the bomb be surrounded by 6 inches of lead, seem to be badly affected. Results from this method have, however, been disappointing, and it has been abandoned.

Radon is yet another form of treatment in which the emanation is collected in a special plant and sealed into glass or metal containers, according to need, and these are applied by the standard methods with the exception that radon capillaries or seeds may be implanted in tumours and left. It will be remembered that the decay period of radon is 3·8 days to half value. At the end of 40 days the seeds become small inert foreign bodies, and do no harm, thus saving further surgical interference for their removal. Some American workers have claimed excellent results in malignant disease of the tongue by the use of radon seeds of gold, though why their results were better than others appears to be a matter of surmise.

Radon is measured in millicuries, and since it has a half-decay period of 3·85 days, it may be asked whether the dosage of radium and radon can be compared. On a physical basis it has been calculated that if radon is left in the tissues indefinitely the number of millicuries present multiplied by 132 will correspond to the equivalent milligram-hours. Tables have been made by Russ, Clark and Waters tc show also (1) the increase of time for which radon seeds must be left in the tissues to compensate for the decay of radon as compared with the radium element, (2) the amount of radon required to give an equivalent physical dose in the same time as that of an amount of radium.

General Opinion as to the Value of Radiation Therapy

In conclusion it may be stated broadly that the opinion of most authorities of a balanced temperament is that in no condition does radiation therapy displace surgery in the treatment of malignant disease. In post-operative treatment it is regarded as helpful. In inoperable cases it may be the only form of treatment available, and in some cases will render inoperable growths operable. It gives, even in cases showing a favourable immediate result, no guarantee of immunity from metastases, and there is reason to believe that with certain methods metastatic action is even accelerated. So far as the work has progressed it seems to the nonbiassed observer that the method has advanced the possible cure of malignant disease but little.

CHAPTER XXIV

ANÆSTHESIA

Alex. F. Potter, M.R.C.S., L.R.C.P., D.A.

For the production of insensibility to pain and for minimising shock to a patient undergoing an operation various drugs are used, acting on the nervous mechanism either centrally (general anæsthesia) or locally (local and regional anæsthesia).

General anæsthesia produces unconsciousness, general muscular relaxation, and diminution of the reflexes; whilst local and regional anæsthesia are designed to produce a temporary block in the nerves in the area of operation, so that this area is cut off from the central nervous system with abolition of pain sensation in that area, the patient remaining conscious.

GENERAL ANÆSTHESIA

Preliminary Examination. Before a patient is to be given an anæsthetic a preliminary examination should be made by the anæsthetist to assist him in the choice of the drug to be used and the method of administration, and to forewarn him of any possible difficulties or dangers which may occur during administration.

A history of previous operations under general anæsthesia and the after-effects should be obtained.

The general appearance of the patient should be noted, especially as to the respiratory movements; any obstruction to respiration, dyspnœa or orthopnœa, call for the greatest care during induction by inhalation.

Observation of the colour of the lips and ears will show any signs of cyanosis.

Examination of the mouth for oral sepsis or loose or broken teeth should be made. False teeth plates should be removed just before the administration is started, while the lungs and heart should always be examined.

The clothing should be adjusted so that there is no tightness around the neck or waist to hinder easy respiratory movements; moreover, all jewellery, such as rings, brooches, bracelets, wrist watches, etc., is best removed, as these are liable to be damaged or to cause injury to the patient during induction.

A few reassuring words by the anæsthetist before commencing the administration often will ease the nervous patient.

Preparation of the Patient. The patient, before being given an anæsthetic, should undergo a certain amount of preparation; this is not possible in emergency cases, when the operation may be necessary at very short notice. Where possible the operation should be at about 9 a.m. A mild purgative is given twenty-four hours before the time for operation, and light, easily digested meals given at the patient's ordinary meal-times for the two days previous to the operation.

No food is given after the evening meal of the day previous to operation, but a cup of tea or coffee, without milk, and a rusk or dry biscuit may be taken three hours before the operation (6 a.m.). It is advisable to exclude milk, as it is liable to clot and remain in the stomach, and so cause vomiting.

In the case of enfeebled patients, 1 ounce of syrup of glucose may be given four-hourly for sixteen hours before the operation, the last dose being given four hours before the time fixed for the operation. In all cases drastic purgation and starvation should be avoided.

The anæsthetic should be given when the patient is on the operating table, as it is undesirable to move the anæsthetised patient more than is absolutely necessary for the requirements of the surgeon.

If possible the induction should take place in a room next the theatre, and not in the theatre; absolute quiet should be maintained until the patient is unconscious.

NITROUS OXIDE GAS

For minor operations of short duration, such as the opening of an abscess, the extraction of a few teeth, the changing of a painful dressing, etc., the inhalation of nitrous oxide will produce anæsthesia sufficient for the purpose. No special preparation is needed, though it is advisable not to give it immediately after a heavy meal; the short narcosis produces no after-effects except occasionally a slight headache.

Nitrous oxide should not be given in cases in which there is any marked obstruction in the upper air passages, such as from enlarged tonsils, cellulitis of the neck and œdema of the glottis, retropharyngeal abscess, etc. Moreover, it should not be used in the case of muscular alcoholic subjects, or for children under six years of age.

Apparatus. Nitrous oxide gas is supplied in liquid form under pressure, contained in metal cylinders, being released in the form of gas by the turning of a key, which may be manipulated by the foot or by hand. From the cylinder the gas passes through a length of strong rubber tubing into the large rubber bag. To the bag is connected a three-way valve, to which is fitted the facepiece.

The bag is half filled with gas and the facepiece applied; for the patient's comfort the size of the facepiece should be chosen so that it fits easily over the mouth and nose; it may also be previously washed in hot water and dried, so that it is warm when applied to the face. The patient is then told to breathe in and out in the normal manner, and after a few breaths the stopcock is turned and the gas passes from the bag to the patient; at the same time the cylinder key is adjusted so that a gentle stream of gas enters the bag until it is just distended. The facepiece is kept firmly held in the left hand, fitting the face closely to prevent leakage, the little finger being used to hold the chin forward.

In this manner the patient inspires gas and expires into the air; if the expiratory valve is closed by turning the key, the patient rebreathes in and out of the bag. This is seldom required, but may be used for a few breaths now and again in a long administration.

A mistake often made is that of filling the bag full with gas, the facepiece being applied and the stopcock turned; the patient is thus alarmed by a sudden rush of gas, which he inhales and becomes very quickly unconscious. This he will remember with fear afterwards and will have a dread of taking gas on future occasions. If the patient breathes quietly and normally from the bag half filled, he will pass gradually into a state of sleep without any unpleasant sensations.

After about four or five inspirations consciousness is lost and the respirations become quicker and deeper; after a few more inspirations a slight stertor and twitching will be noted, with the commencement of cyanosis. At this point the facepiece should be removed and, in dental cases, the jaw held up by the right hand to fix the dental prop in its position, and the left hand kept free to insert a gag, if desired by the dentist.

The dental props should not be removed when the patient is semiconscious.

If the operation is not about the mouth, the facepiece may be kept on, but the stopcock should be opened to admit air for two breaths and then closed again, thus avoiding stertor and jactitations when more gas and air can be given; in this manner the anæsthesia may be prolonged for from two to three minutes.

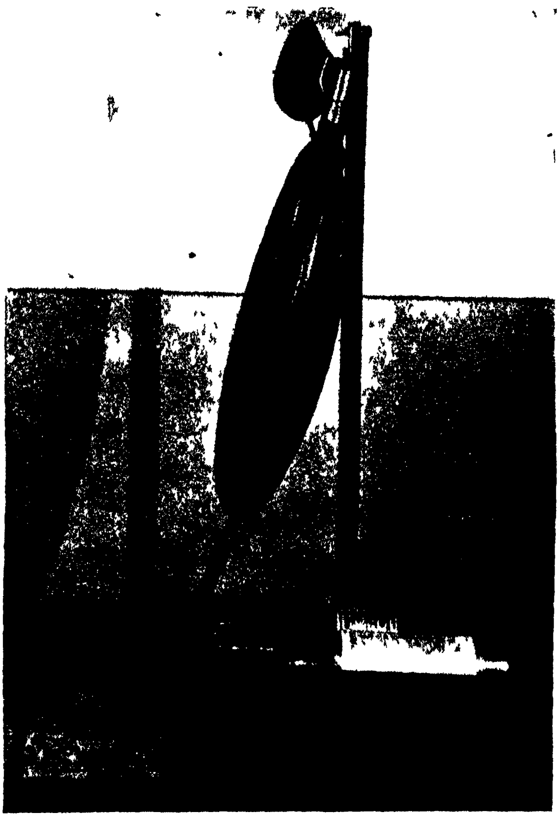


FIG. 384. *Nitrous oxide cylinders fitted with a foot key and connected to a rubber bag, Hewitt's valve and facepiece.*

Nasal Administration of Nitrous Oxide. For more prolonged administration, the method of continuing the inhalation by the nose may be used by means of the apparatus of Trewby or Coleman, which consists essentially of a bag contained in a string net or metal bands to compress the gas and connected to the cylinder by a long pressure tubing. From the bag the gas, under gentle pressure, passes through a valve at (A) along two tubes (B) attached to the nosepiece which is fitted with an expiratory valve (C). To the nosepiece is fitted a wide-bore tube (D) leading the gas to the mouthpiece;

when the mouthpiece is removed from the mouth and turned aside the supply of gas to this tube is shut off, but it continues to the nosepiece only. By pressing the valve holder (C) downwards an aperture is made for the admittance of air, at the same time cutting off the supply of gas. To commence with, both the facepieces are applied, and when the signs of anæsthesia are produced the mouthpiece is swung aside and the intake of the gas maintained by the nose only. By this means anæsthesia is maintained whilst longer operations about the mouth are performed.

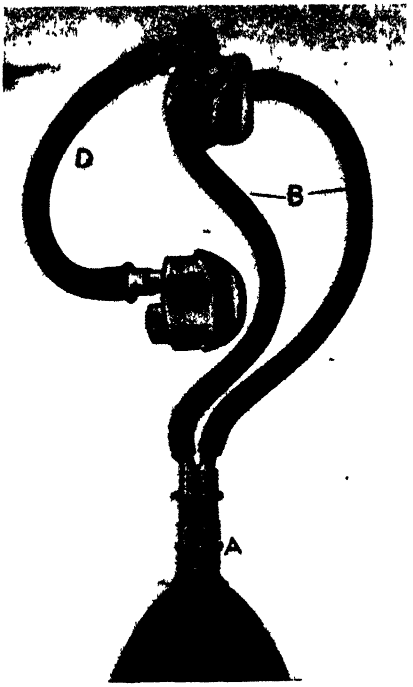


FIG. 385. Trewby's apparatus.

A simpler apparatus, but one which requires considerable skill and practice to use successfully, is one consisting of the nosepiece alone, attached to the bag and fitted with a valve and air-holes. Induction is produced by instructing the patient to breathe through the nose only; as soon as anæsthesia is obtained the operation is commenced and the pressure in the bag gently increased, holding the nosepiece in position until completion of the operation. These methods are obviously unsuitable if nasal obstruction is present.

Cyanosis occurs more readily by these methods, and should be avoided by judicious use of the valves or by combining oxygen with the gas (see below).

The after-effects of a prolonged gas administration are sometimes marked, and recovery is less rapid.

NITROUS OXIDE AND OXYGEN

To enable a mixture of oxygen with nitrous oxide to be given by the nasal method a metal ⅄-shaped tube is fitted into the tube from the gas cylinder, so that a tube from an oxygen cylinder may be attached to the second arm and a gentle stream of oxygen allowed to run in and mix with the nitrous oxide before it reaches the nosepiece.

The oxygen cylinder should be fitted with a reducing valve, and by regulating the mixture cyanosis may be prevented.

For the administration of nitrous oxide and oxygen for prolonged operations where large amounts of ether and chloroform are contra-indicated, many types of apparatus have been designed. A simple *continuous flow* apparatus is that designed by Boyle.

Other more complicated types of machine are made on the *intermittent flow principle.* One such type is the American McKesson machine, in which gases flow only on inspiration at known pressures through a mixing valve having fine adjustment readings in percentages.

An air-tight fitting to the patient's face, a clear open air way and correct pressures and percentages are essential. An ether chamber is incorporated in the machine so that this vapour may be added when necessary.

A soda-lime carbon dioxide absorber is fitted into the circuit so that this technique may be employed (see below). The anæsthetist should acquaint himself with the different types of machines and assess for himself the advantages and disadvantages in each apparatus. Only by constant practice can he become proficient with the apparatus which he eventually decides to use.

As the Boyle type of apparatus is simple and commonly used in this country, a description of this will be given.

The nitrous oxide and oxygen are led from the cylinders, each provided with a fine adjustment reducing valve, into a bottle containing warm water into which dip two metal perforated tubes. The gases are seen to bubble into the water, and the reducing valves are manipulated so that the correct mixture is bubbled into the bottle. In place of the perforated tubes, the *flowmeter* may be used (Fig. 387). This consists of glass tubes, each containing a light bobbin, which is raised by the flow of gas. The tubes are graduated accurately, measuring the flow in litres per minute.

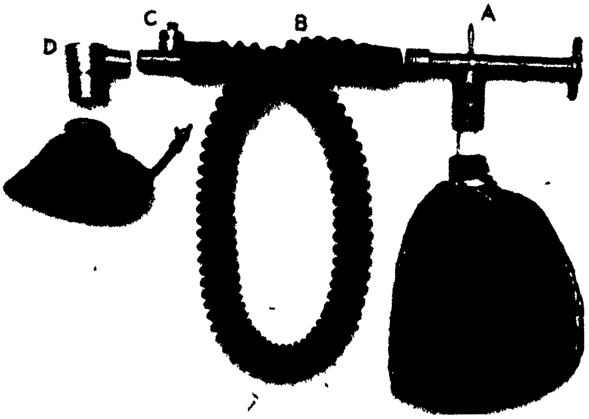


Fig. 386. Magill's apparatus.

From this, the mixture is passed through a two-way valve, directing it either through a bottle containing ether, or directly through to a wide-bore tube connecting the facepiece to a small rubber bag. By means of a valve which is opened and closed by moving a lever over a semicircular scale the gases may be directed either (*a*) straight into the wide bore-tube, or (*b*) partly, or (*c*) entirely through the ether bottle, according as the lever is turned to different degrees between the ON and OFF mark on the scale. With the lever at ON, the gases pass through the U-shaped tube A in the ether bottle. Over the end of the tube is fitted a cap, which is raised or lowered by means of a rod, B.

When the cap is raised, the gases pass over the surface of the ether; an increasing concentration of the vapour is obtained as the cap is lowered to direct the stream nearer the surface of the liquid.

When the cap is plunged down to overlap the tube, the gases bubble through the liquid, giving the greatest concentration. In this manner the amount of ether inhaled is more accurately measured.

The apparatus is also made to include a third bottle in the circuit, to contain chloroform (Fig. 387).

From the wide-bore tube the mixture passes to a small bag (Magill's apparatus, Fig. 386) fitted with an "on" and "off" valve (A) to enable rebreathing if required. From the bag the gases pass along a length of wide-bore concertina-tubing (B) to an expiratory spring-valve (C). This valve is connected to an angle-piece (D) which leads to the facepiece. The expiratory valve can be fitted directly on to a nasal tube or catheter for intratracheal administration.

To produce a prolonged quiet anæsthesia by this method requires experience of the apparatus.

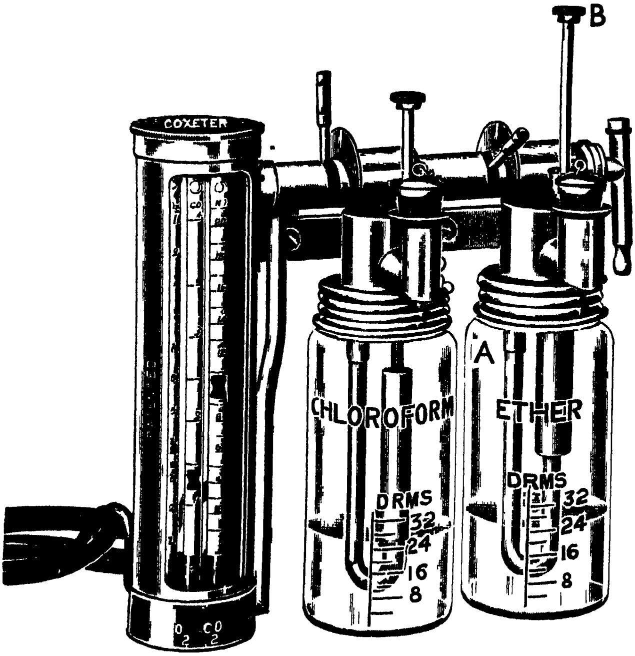


FIG. 387. Boyle's apparatus with flowmeter attached.

Methods of Administration. The patient should be given a hypodermic injection of atropine, gr. $\frac{1}{100}$, and morphia, gr. $\frac{1}{6}$, half an hour before operation. For a prolonged administration, the use of some form of basal anæsthetic, such as avertin, is advisable (see p. 784). The apparatus should be tested before use. The facepiece is applied and a gentle stream of nitrous oxide turned on, and after a few breaths the oxygen is slowly added.

By carefully watching the respirations and the colour of the patient the correct mixture is arrived at, usually about N_2O 4 parts, oxygen 1 part. If cyanosis becomes marked more oxygen is turned on, though a very slight degree of cyanosis is not harmful; if narcosis becomes lessened, more nitrous oxide is allowed to flow.

In order to keep up a positive pressure a certain amount of rebreathing may be allowed, by closing down the expiratory valve and distending the bag.

When the correct mixture has been obtained the patient settles down to a quiet, easy narcosis, the colour remaining good and the respirations even. When this state is reached a steady, even flow of gases is maintained and the operation commenced. Three or four minutes may be required before this satisfactory state is obtained, but it is always worth while spending sufficient time to get the patient quietly anæsthetised before allowing the surgeon to commence, as the anæsthesia will remain smooth throughout the whole operation; whereas if the operation is commenced before the correct mixture is attained and the patient breathing quietly, continual trouble will be given to the anæsthetist and the surgeon throughout the proceeding.

If complete relaxation is needed during a part of the surgical procedure, the valve may be turned so that the gases are passed through the ether in the bottle; while, if required, the apparatus may be modified so that the mixture may be conducted through an intratracheal catheter placed in the trachea (*see* Intratracheal Anæsthesia, p. 781).

It must be remembered that the anæsthesia produced is light and short, and therefore the minimising of shock during a major operation is not so complete as with a deep anæsthesia.

It is probable that deaths occurring during or shortly after a major operation under gas and oxygen anæsthesia are due to shock and sudden cardiac failure.

As with gas and oxygen anæsthesia the muscular relaxation is not complete, the surgeon should co-operate with the anæsthetist in seeing that any manipulation of organs during an abdominal operation should be very gentle and reduced to a minimum, while the local infiltration of the area of operation with 1 per cent. novocaine will be found of considerable value (see p. 795).

Gas and oxygen alone is unsuitable for strong, muscular or alcoholic subjects, for children under six years of age, or for operations about the rectum or bladder. In using gas and oxygen anæsthesia for major operations, some form of premedication should always be employed and sufficient ether used to produce the necessary depth of narcosis to combat shock.

Difficulties and Dangers arising during Anæsthesia under Nitrous Oxide or Nitrous Oxide and Oxygen. (1) From the *aspiration* of blood, vomit, broken or extracted teeth, pus from an abscess, etc. These may cause asphyxia from spasm of the larynx or a secondary septic pneumonia.

When signs of asphyxia are detected the mouth should be sponged out, the head lowered, and foreign bodies searched for and removed, if possible. The tongue is held forward, but not drawn out, as by this means the larynx is opened for a foreign body to fall in.

A stream of ether vapour may be directed into the mouth to excite the patient to cough and clear the air passage for himself. As soon as it is made certain that no foreign matter is blocking the air passage, the tongue may be drawn out and artificial respiration started with the patient in the prone position. If this fails, the laryngoscope should be used to pass a tube into the trachea and a stream of oxygen or oxygen and carbon dioxide supplied.

(2) *Cardiac failure* is a serious complication which may occur, fortunately very uncommonly, and is due to prolonged cyanosis and deprivation of oxygen; thus it should not occur if proper precautions are taken to avoid a prolonged cyanosis.

CYCLOPROPANE

Cyclopropane (C_3H_6) is a powerful gaseous anæsthetic on which recent experimental work has been and is being done. It is supplied in cylinders liquefied at a pressure of 75 lbs. per square inch. It has a slightly pungent odour, is heavier than air, is inflammable and forms an explosive mixture with oxygen. The gas is administered and measured by means of a special flowmeter attached to one of the gas and oxygen machines, in which is incorporated a carbon-dioxide absorber.

Being a potent anæsthetic gas, cyclopropane can produce narcosis in a concentration of 4 per cent.; as the depth increases the moving eyeball becomes fixed at about 13 per cent., and at 23 per cent. occur muscular relaxation and commencing intercostal paralysis. Thus a high percentage of oxygen can be used and is indeed essential for safety, when regulating the mixture to be given.

In these small percentages the toxicity of the gas is small and recovery rapid. There is no respiratory stimulation during induction as is seen with nitrous oxide, and most other inhalation anæsthetics. It is important to remember that with increasing percentages of cyclopropane only very slight changes occur in the respiratory rhythm and depth, so that an overdose may be given without any warning respiratory signs.

It is essential therefore to watch carefully the pulse rate and volume, as variation in this is the only warning of a dangerous concentration.

Owing to the high percentage of oxygen used the colour remains good, although the concentration of cyclopropane may be reaching dangerous levels.

Warning signs of a too high concentration of the gas are shown by alterations of the pulse, usually a slowing followed by arrhythmia and tachycardia. These signs indicate an immediate reduction in the gas and an increase in the supply of oxygen.

Induction should be slow and gradual; starting with pure oxygen after a few breaths, cyclopropane is turned on and run at from 300 to 400 c.c. per minute. After about five or six minutes the patient settles into a quiet relaxed anæsthesia and the cyclopropane is turned off, the carbon dioxide absorber being in use.

A small flow of oxygen is maintained and very small quantities of cyclopropane added to replace loss or to increase the depth of anæsthesia when required. An air-tight fitting mask and a clear airway are essential for maintaining a smooth anæsthesia.

Carbon dioxide absorption

In any closed apparatus in which rebreathing takes place, the carbon dioxide expired by the patient is necessarily retained, and this piling up of carbon dioxide eventually leads to excessive respiratory stimulation, rise of blood pressure and pulse rate.

In order to absorb the carbon dioxide, the principle of passing the expired gases through soda-lime is adopted.

It is known that volatile anæsthetic gases are excreted by the lungs unchanged, so that by using a completely closed circuit and by absorbing all the carbon dioxide, when sufficient anæsthetic has been administered to produce the required depth of anæsthesia, the supply can be cut off and the vapour in the closed apparatus be used continually by to and fro breathing through the absorber, to maintain anæsthesia. It is necessary, however, to supply a small flow of oxygen to replace that used by the tissue in normal metabolism. By this means a near approach to normal physiological conditions in the patient is maintained during the state of anæsthesia.

Dr. R. Waters, who has done much experimental work in carbon dioxide absorption technique, advocates as essentials :—

(1) The use of a canister containing the soda-lime, avoiding obstruction to breathing, and placed next to the facepiece or catheter to obviate the risk of dead space and to ensure all the expired gases coming into contact with the soda-lime.

(2) The maintenance of a completely free air-way, by the use of suitable air-way tubes or intratracheal catheters.

(3) Air-tight fitting between the patient and the apparatus.

Any leakage either around the facepiece, the intratracheal catheter or in the connections of the apparatus will nullify the principles of the closed system.

ETHER

Preparation of the Patient. In addition to the ordinary preparation, as described on p. 763, before ether anæsthesia a hypodermic injection of atropine, gr. $\frac{1}{100}$, should be given half an hour before operation. In young children this is preferably given by mouth. This lessens the excessive secretion of mucus which accompanies ether inhalation, and so helps to prevent post-anæsthetic bronchitis; it also aids considerably in the prevention of post-anæsthetic vomiting, which is due in great part to the swallowing of mucus impregnated with ether during induction.

Atropine also, by its action in depressing vagal activity, lessens the liability to vagal inhibition affecting the heart; this action, however, is of more importance during chloroform administration (see p. 786).

In cases suffering from shock, or in those cases in which it is anticipated that the operation, from its severity, will cause much shock, an injection of morphia, gr. $\frac{1}{8}$, should be given in addition.

Methods of Administration. (1) *By Inhalation*

(A) Open method.
(B) Closed method.
(2) By insufflation :
Intratracheal method.
(3) By the rectal method.

Apparatus. When administering any anæsthetic by inhalation certain apparatus should be kept at hand on the anæsthetist's table.

Mask. The most suitable form of mask for ether inhalation is the *Schimmelbusch metal frame mask,* the frame holding two layers of thick lint, cut so that it extends over the base for about 2 inches.

Low's mask is preferred by some; this, consisting of an oval-shaped metal cage covered with three or four layers of gauze, is fitted on to a rubber facepiece.

Drop Bottle. The ether is contained in a bottle holding 6 or 8 ounces, and fitted with a rubber cork through which run two small-bore metal tubes, the one reaching to within $\frac{1}{2}$ inch of the bottom of the bottle, so as to admit air to the bottle, the ether running through the shorter tube as the bottle is tipped up. Between the mask and the patient's face is placed a square of gamgee tissue with a circular hole cut out of the centre to expose the patient's mouth and nose, and at the same time to protect the eyes from damage from ether vapour or from the rim of the mask. A second piece of gamgee tissue should be at hand to place over the mask when further concentration of the vapour is needed.

Gag. A molar gag, such as a Mason's gag.

Hewitt's airway is perhaps the most useful adjunct to the anæsthetist's apparatus. It consists of a curved stout rubber tube fitted with a metal flanged opening, placed between the teeth, the rubber tube resting on the back of the tongue.

Tongue Clip. Some form of tongue clip should be ready for drawing out the tongue quickly; a type that pierces the tongue, making only a small punctured wound, is the best type. The old tongue-gripping forceps are liable to cause much damage, and are never necessary.

Spongeholders and small sponges may be required to sponge away thick stringy mucus, etc., obstructing the air passages.

Small gauze plugs are useful to soak up excessive mucus.

A laryngoscope, catheter and nasal tubes to intubate and give a direct supply of oxygen and carbon dioxide.

(A) **The Open Method.** This method is actually seldom used for induction, being slow and unpleasant to the patient, but the sequence of events occurring during induction with ether is similar whatever method is used, and these will be described here.

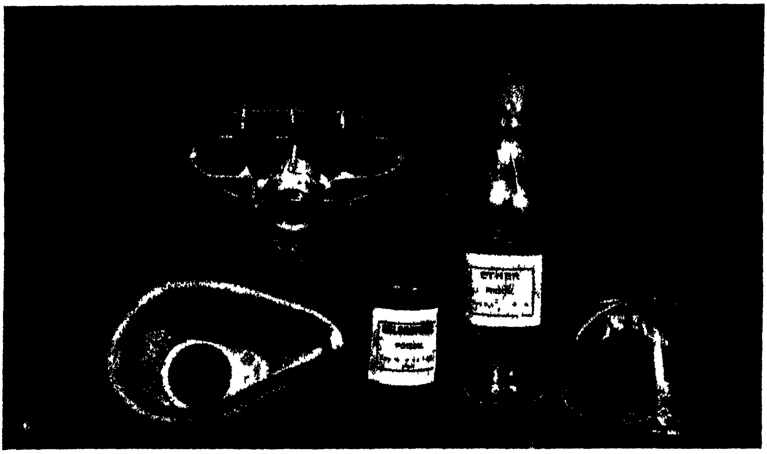


FIG. 388 A, Rubber facepiece. B. Low's mask. C. Chloroform drop bottle. D. Ether bottle. E. Schimmelbusch mask.

The patient being placed on the table, and the preliminary examination having been made beforehand if possible, the head is turned to one side away from the operator, the gamgee tissue placed over the face, and the mask held a little way from the mouth with the left hand, which is also used to hold the point of the jaw forward, and the ether dropped on slowly with the right hand.

The patient is told to breathe naturally and not to hold the breath. The first few inhalations of the vapour cause coughing and a feeling of suffocation; this can be greatly avoided by very gradual administration. At times the secretion of mucus becomes noticeable and swallowing movements take place; this may be dealt with by packing a small gauze plug in the lower cheek, the end of the plug lying free outside the mouth. The mask is then gradually placed closer to the mouth until it lies over the mouth and nose, resting on the pad of gamgee tissue. The ether bottle is held about

2 inches from the mask, allowing a continual slow succession of drops to fall, so that a constant, gradually increasing supply of vapour reaches the patient.

Phenomena of Ether Anæsthesia. After a few inspirations the skin becomes flushed, the respirations increased in rate, the pulse rate is increased, and the tension soft and full. Later, the respirations are deeper and fuller, and consciousness is gradually lost. As the controlling centres become in abeyance involuntary movements and incoherent speech may take place, and some cases pass into a state of great excitement, in which the patients may shout and struggle; this, however, usually occurs only in strong muscular or alcoholic subjects.

At this stage the movements should be controlled lightly and not forcibly, using such force as is necessary only to prevent the patient injuring himself or bystanders.

Care must be taken in this stage to watch the respirations, as spasm of the larynx or rigidity of the muscles of respiration may cause a cessation of breathing, so that cyanosis appears; the mask should then be raised slightly and gradually replaced as the breathing becomes regular again.

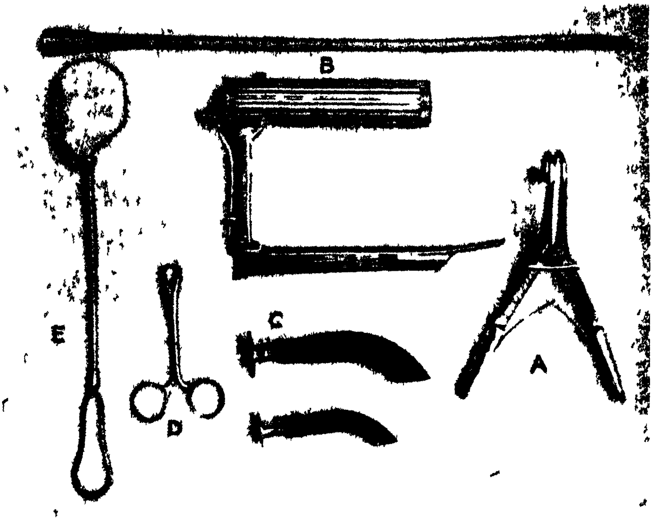


FIG. 389. A. Mason's gag. B. Laryngoscope C. Hewitt's airway. D. Tongue-clip. E. Sponge-holder.

With care and skill this stage of excitement may be reduced to a minimum, and in most cases is not evident at all; in this interest it is important to avoid a sudden increase in the strength of vapour presented by adding small quantities often, rather than a few large doses.

The patient now settles into a condition of rest, the muscles relax, the respirations become regular and deep, the pupils commence to dilate. Occasionally a marked perspiration occurs over the whole body, and patches of urticarial rash (the ether rash) appear on the chest, neck and face; these, however, are transient and are usually not evident at the end of the operation.

In some cases an "*ether tremor*" occurs, in which a prolonged elonic muscular spasm takes place, and which is sometimes very troublesome and difficult to control.

The pulse rate slows to normal, though remaining fuller, and the blood pressure is higher than normal.

With a gradually increasing supply of vapour the patient passes into a state of complete relaxation, the muscles becoming flaccid, the respirations more shallow, the pupils dilated, and the corneal reflexes lost. From now onwards during the operation the anæsthetic should be dropped on in a continual slow drop, and far less is now needed to maintain the condition of anæsthesia.

The depth of anæsthesia to be maintained will vary with the nature of the operation, and the anæsthetist should endeavour to administer the least quantity possible to maintain anæsthesia sufficient for the operation.

Thus for an operation on the gall-bladder a large quantity of anæsthetic will be needed to maintain complete relaxation and small respiratory movement, whereas for an operation such as for removing a lipoma a very light narcosis is sufficient, and the after-effects will be practically nil.

Conducting the Anæsthesia. During the whole of the operation the attention of the anæsthetist should be constantly applied to the patient and to the manipulations of the surgeon. Only by constant attention can the signs of danger be noted, which, if dealt with early, can almost always be rectified.

By far the most important point to note is the character and depth of the *respirations*. With a clear airway and easy, regular respiratory movements maintained throughout, little trouble need be anticipated.

If the air passage is not clear, no time should be lost in inserting the Hewitt's airway, though it must be remembered that unless the patient is well under the anæsthetic attempts to put in the airway are useless, and do more harm than good, for it will only cause irritation, coughing, and perhaps vomiting. It is therefore necessary in the first place to open the mouth slightly with the gag, and perhaps draw the tongue a little forward and apply the mask. If the teeth are clenched tightly, a short rubber nasal tube should be passed through the nostril into the naso-pharynx. As soon as a good, constant supply of the vapour reaches the lungs the anæsthesia will be deep enough to enable the airway tube to be borne and so maintain a clear airway for the rest of the operation.

The *colour* of the patient should be watched and cyanosis avoided.

Cyanosis necessarily means an obstructed airway and deprivation of oxygen ; this can be remedied by inserting the airway tube and administering a little oxygen.

When once the patient is sufficiently deep it is beneficial to give a very small stream of oxygen for the duration of the administration.

In very deep narcosis cyanosis may appear ; this indicates lessening the vapour supply and giving more air or oxygen.

The *pulse* is conveniently noted by a finger over the superficial temporal artery in front of the ear ; this should also be felt before the anæsthetic is administered, so that any variation in its force and rate can be compared.

The *eye signs* during ether anæsthesia are of little value, as they are by no means constant in every patient. The size of the pupil is large during deep ether anæsthesia, and gradually contracts to normal size as the anæsthesia becomes lighter. It must be remembered that the pupil will become dilated under a light anæsthesia during surgical manipulation, this being due to shock and calling for deepening of the anæsthesia.

On recovery from an anæsthetic, and previous to the stimulus of vomiting and retching, the pupil is often found to be dilated. The influence of atropine in dilating the pupil and morphia in contracting it should be borne in mind where these drugs have been administered.

The *conjunctival* and later the *corneal reflexes* are lost during deep anæsthesia, but here again these signs alone are of little value in estimating the condition of the patient, and the practice of continually touching the conjunctiva and cornea to elicit the presence or absence of these reflexes is wholly unnecessary and risks serious damage to the eye. Movements of the eyeball laterally are noted as the anæsthesia becomes light, being absent during deep anæsthesia. During anæsthesia the *lacrymal secretion* is increased and a small pool collects in the canthus; the presence of this is a helpful sign in that, if an overdose is given, the eye becomes quite dried, and if the canthal pool is wiped away it does not reappear. This condition should not be allowed to occur, as it is an early sign of overdose.

As regards observation of the eye signs, all that is necessary is occasionally to lift the lid and observe the size and fluctuations of the pupil, movements of the eyeballs and the lacrymal secretion, care being taken not to allow vapour, liquid ether, or anything else to irritate or damage the surface of the eyeball. After removal of the mask at the end of the operation it is advisable to drop into each eye one drop of pure olive oil.

Recovery and the gradual return of consciousness after anæsthesia manifest themselves in a variety of ways in different patients, some simply wakening quietly and quickly, others becoming excited, noisy and boisterous.

The length of time of recovery usually depends on the depth of anæsthesia maintained, those who have required a large amount of vapour taking longer to " come round " than those who have taken little anæsthetic.

The patient should be covered with blankets in a warmed bed, as he is removed from a hot theatre to the lower temperature of the bedroom or ward. No hot-water bottles should be left in the bed. The head should be turned to one side and not raised. Careful watch should be kept by the nurse until consciousness is regained, especially if vomiting occurs, to see that the vomit does not choke the air passages, to prevent him injuring himself by undue movements, or from tearing at dressings or removing the bedclothes. The pulse should be noted at frequent intervals; it is common for the pulse to become quickened and feeble just before the act of vomiting, and this may cause alarm; but after vomiting has taken place the pulse usually settles again.

Difficulties and Dangers during Ether Anæsthesia. (1) *Coughing and respiratory embarrassment* during induction are caused by a too sudden increase in the vapour, and can be avoided by increasing the strength of vapour very gradually.

Respiratory obstruction occurs in patients with a small, receding lower jaw, the tongue falling back and closing the air passage; in these cases the angle of the jaw should be held firmly forward by the thumb and the tongue held forward. In edentulous cases a small prop or a gag, slightly opened to separate the lips, should be employed to prevent the lips being sucked in and acting as a valve, which stops inspiration; as soon as possible the airway tube should be inserted and held in position.

Spasm of the masseter muscles, closing the mouth, calls for the administration of oxygen and insertion of a gag between the teeth, or a nasal tube may be passed and oxygen and CO_2 passed through it.

(2) *Retching or vomiting* during anæsthesia is due to insufficient vapour being given to maintain anæsthesia; warning is given of this by the respiration becoming irregular and shallow and by swallowing movements.

These events call for an increased supply of ether, but if vomiting has actually occurred the mouth should be well sponged out before increasing the ether supply.

Signs of shock occurring during the operation may be due to the severity of the operation alone, but may also be due to an insufficient amount of ether being given, in which case it is advisable that the surgeon ceases his manipulations for a short time whilst more ether is administered and a deeper anæsthesia produced.

(3) *Overdose* is shown by a change in the respirations from a regular rhythm to a shallow, slow or jerky breathing until respiration ceases. The pupil becomes widely dilated and the eye dry and fixed.

Cyanosis occurs, and gradually increases, from insufficient oxygen aeration of the blood. If careful watch is kept on the respirations and the appearance of cyanosis, the cessation of respiration from overdose should never occur. Immediate recourse to artificial respiration and giving of oxygen and CO_2 will soon restore regular respirations.

After-effects of Ether Inhalation. (a) *Immediate.*

(1) *Vomiting*, if it occurs, is usually slight, but occasionally may be excessive, and if it persists is a serious feature. Moistening the lips and teeth with vinegar at the end of the operation may tend to arrest vomiting.

Glucose given by mouth before the operation is beneficial in this respect.

If it continues the stomach may be washed out, either by giving a tumblerful of warm water containing sodium bicarbonate, grs. xxx, which is returned by vomiting, and cleanses the stomach so that further vomiting ceases; or, if this fails, the stomach tube must be used. Nothing should be given by mouth except occasional sips of warm water. To allay thirst, saline may be given per rectum. A hypodermic injection of lobelin, 1 c.c., given immediately after the anæsthetic is said to prevent post-anæsthetic vomiting. Its action produces an increased rate and depth of respiration, and so hastens elimination of the vapour. A similar action is produced by the administration of carbon dioxide gas immediately after the termination of the operation. Repeated doses of Tinct. Iodi., ♏i, or an occasional tablet of cocaine, gr. ¼, by the mouth, may prove useful.

The administration of saline, ℥x, and aspirin, grs. xv, per rectum often helps to obviate vomiting.

(2) *Cyanosis and dyspnœa* may arise from a faulty position in the bed, or from vomit, blood or mucus obstructing the airway or aspirated into the trachea. A gag and mounted sponges should be at hand to deal with these dangers.

These complications are more likely to occur when morphia or other narcotics have been given before the operation, and whilst the patient is still deeply under the anæsthetic.

(3) *Signs of collapse*—a rapid, feeble pulse, shallow, quickened respiration, a blanched, cold, clammy appearance—may show themselves after a prolonged deep anæsthesia.

This is due in part to surgical shock, but may be due to exhaustion following overstimulation from ether, this being especially liable to occur after a prolonged administration of ether vapour with oxygen.

The treatment should be directed to the giving of morphia, gr. ¼, by hypodermic injection, raising the foot of the bed, applying hot-water bottles, the rectal administration of saline, and towels wrung out in hot water applied to the head (see also p. 52).

When a condition of collapse is manifest, one should hesitate to treat it immediately by intravenous infusion of saline; for here we have the cardiac action greatly weakened, as evidenced by the feeble, rapid and "stringy" pulse; it is obvious, therefore, that a somewhat sudden addition of a bulk of fluid may be more than the enfeebled heart can deal with, thereby producing complete failure in its action.

In cases in which the collapse is due to severe hæmorrhage during operation the condition is of a different order, and the infusion of saline and gum or transfusion of blood to replace the lost fluid, if allowed to flow in very slowly, is successful in restoring cardiac action.

In cases in which, before operation, it is surmised that considerable shock will be caused, the anæsthetist would advisedly give a continual subcutaneous saline infusion. By this means a slow absorption of saline is taking place during the whole operation, and commences before the heart's action has become enfeebled by shock.

(4) *Convulsions*, a phenomenon occasionally seen in patients after a prolonged, deep ether anæsthesia, consists of a series of jactitating movements not accompanied by cyanosis, affecting all the muscles of the body, and totally different from the ether tremor previously described. These movements frequently commence in the facial muscles and spread to the extremities. It is possible that the condition is due to oxidation impurities in the ether or to over-oxygenation, as it has been known to occur in those cases in which prolonged oxygen administration has been given with the ether. It has been ascribed by some observers as due to heat stroke, its cause, however, has not been definitely elucidated.

An intravenous injection of evipan may be given to control the convulsions.

(b) *Remote.* Of the remote after-effects, the *pulmonary complications* which sometimes occur are the most common. The bronchitis and bronchopneumonia which occur are usually slight, and a history of a previous cough or cold can usually be elicited in these cases. The severe cases of bronchopneumonia which rarely occur are caused by the aspiration of septic material from the teeth or mouth.

The expectorant action of a small quantity of ether vapour during a short light anæsthesia may often have beneficial effects on a previous mild bronchitic condition.

As a preventive of severe pulmonary complications after ether inhalation in cases showing some signs of bronchial trouble before operation, but in which ether is not definitely contra-indicated, a hypodermic injection of the following mixture may be given :—

℞ Adrenalin (1 : 1000)	♏v
Atropine sulphate	gr. $\frac{1}{200}$
Strychnine hydrochloride	gr. $\frac{1}{100}$
Distilled water	to ♏x

This may be given every four hours up to five or six doses. It should be remembered that its action causes an increase in the pulse rate.

The inhalation, at the end of the operation, of carbon dioxide 5 to 10 per cent. with oxygen has a beneficial effect in expanding the lungs and hastening the elimination of the anæsthetic by its action in increasing the respiratory rate and amplitude.

If, however, there is a considerable amount of mucus secretion in the mouth, carbon dioxide should not be used, as there is a risk of the mucus being drawn down into the bronchi and bronchioles.

In mild cases the administration of an expectorant mixture is usually successful.

(B) **The Closed Method.** *Clover's Inhaler.* To overcome the difficulty and the discomfort caused to the patient, and the slow induction which is entailed by the use of ether alone, the giving of nitrous oxide followed by ether is made use of, ether alone being seldom used for induction.

By means of a wide bore modification of Clover's inhaler the nitrous oxide is passed into an ordinary gasbag fitted with the inspiratory and expiratory valve, as in the administration of nitrous oxide. Between this valve and the facepiece is fitted the metal ether chamber.

This chamber consists of a round metal bulb, through the centre of which passes a hollow tube open at each end ; one end is fitted to the valve of the bag, and the other to the facepiece. Within this tube is a similar movable tube fitted to a lever or handle which can be turned, through a semicircle, outside the ether chamber. The ether chamber holds about 2 ounces of ether, which is passed in through an opening placed at the top of the chamber and closed by a stopper. On the outside of the metal chamber the excursion of the lever is marked from " 0 " to " Full." When the lever is at " 0 " no ether is inhaled ; as it is moved up to " Full " an increasing surface of ether is exposed to the inhaled gas and air.

Method of using Clover's Inhaler. With a little practice and attention to a few details the use of this method will be found to be the easiest and most rapid, as well as the most pleasant method to the patient, of inducing anæsthesia.

Having connected up the facepiece and the gasbag to the ether chamber, 2 ounces of ether are poured into the cup and the stopper replaced. The patient's face is turned to the right, the anæsthetist holds the metal chamber in the right hand, and, making sure that the lever is at " 0 " on the indicator, the facepiece is held closely and comfortably on to the face with the left hand, while the patient is instructed to breathe naturally in and out.

A small stream of gas is then turned on, and as the bag is filling the valve is turned so that the patient inhales gas and exhales into the air. After four or five breaths, the bag being about three-quarters full, the expiratory valve is closed and rebreathing takes place ; the gas is now turned off and disconnected. After a few more respirations the patient is anæsthetised by the gas, and the lever is turned slowly from the " 0 " gradually up to the " ¾ " or " Full " mark. To prevent cyanosis, the inspiratory valve is opened every four or five breaths to allow one inhalation of air.

After from three to four minutes the patient is fully anæsthetised by ether and the gasbag and valves may be replaced by a small bag, air being admitted occasionally by lifting the facepiece during inspiration.

The important details to note are :—

1. Do not overfill the ether chamber, and always hold the chamber so that the cup and stopper are uppermost.
2. See that the indicator is at " 0 " before starting.
3. Fit the facepiece closely so that no air leaks in around it, otherwise struggling and a prolonged induction is caused.
4. Do not commence exposing the ether vapour until the patient is quite " under " the gas.

5. Move the lever very slowly, as too rapid a concentration of ether will cause coughing and respiratory embarrassment.

When the operation has been commenced the lever may be kept at "Full" or turned back to "¾" or "½," according to the depth required for the operation being performed.

After each operation the facepiece and bags should be washed out with soap and water.

Some prefer to use this method for inducing anæsthesia only, discarding the Clover's apparatus, and maintaining anæsthesia by the open method for the remainder of the operation.

FIG 390 Clover's ether inhaler connected to a nitrous oxide apparatus, for the gas-ether sequence method of induction.

Contra-indications. 1. In patients with a severe degree of bronchitis or emphysema ether should not be used, as it is liable to excite cough, and the excessive secretion of mucus in the bronchial tubes may lead to respiratory embarrassment and cyanosis.

2. Patients with very high blood pressure and thickened, rigid arteries undergo the risk of rupturing a vessel and cerebral hæmorrhage, the ether tending to raise the already high blood pressure.

3. Ether vapour, being highly inflammable, should not be used near a naked light or in operations in which the cautery or diathermy spark is used.

4. In tropical climates the use of ether is impracticable.

Special Methods and Apparatus. For operations about the face or mouth, when a mask obviously cannot be kept on the face, the use of **Shipway's apparatus** enables a constant supply of ether vapour to be supplied by means of a tube placed in the mouth or a small rubber catheter through the nostril.

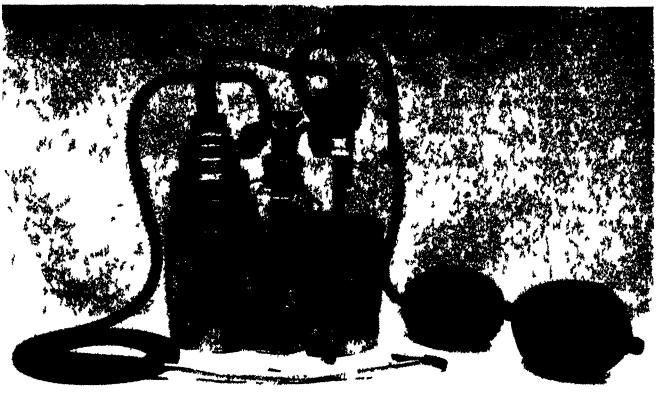


Fig. 391. Shipway's apparatus for the administration of warmed vapour of ether, chloroform or mixture

Shipway's apparatus consists of —

1. A large bottle, containing ether, fitted with a rubber cork through which pass two metal tubes and a three-way valve.
2. A smaller bottle, containing chloroform.
3. A U-tube held in a thermos flask containing hot water.
4. A rubber hand bellows, by means of which air is pumped through the ether (see Fig. 391).

The ether vapour is then passed, by means of turning the valve, either through the chloroform bottle or directly to the U-tube, and so to the metal tube held in the mouth. By this means a continual supply of warmed ether or mixed ether and chloroform, or chloroform vapour alone, can be administered. The two bottles are held in metal cups, into which may be put warm water to increase the strength of the vapour.

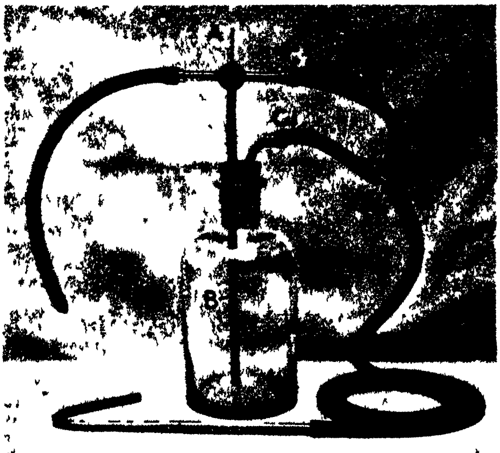


Fig. 392. The Mennell valve.

As an alternative to using the hand bellows an oxygen cylinder may be attached, so that oxygen instead of air is bubbled through the bottles. This method is useful in the operation of tonsillectomy and curetting of adenoids.

The Mennell valve is a simple two-way valve worked by a small metal lever (A) directing a stream of air or oxygen either down a long metal perforated tube (B) or directly across to the delivery tube (C) (Fig. 392). The valve and tube are held in a rubber cork, the long tube dipping into the ether or chloroform and the short delivery tube leading to the patient.

With the lever in the " on " position the oxygen bubbles through the ether and the vapour is led through the small delivery tube (C_1). In the " off " position the stream of oxygen passes directly to the delivery tube (C).

A warning should be given as to the inflammability of a heated mixture of ether and oxygen. A fatal accident has been reported, caused by the explosion of a mixture of ether and oxygen brought about by the heated nozzle of a dental syringe used during a dental operation under ether and oxygen.

Intratracheal Anæsthesia. This method of introducing a stream of anæsthetic vapour directly into the trachea through a tracheal catheter is especially useful in all cases of operation about the head, face, jaw, tongue, mouth and throat, the thorax or lungs.

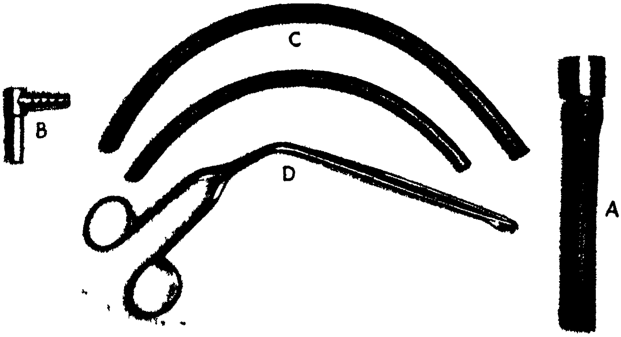


FIG 393 A. connection from expiratory valve of machine to B. metal angle piece to C. nasal catheter. D. Magill's forceps.

The catheters are of firm rubber or silk-woven, the size varying with the size of the glottis ; usually one may say that No. 21 is suitable for the adult female, and No. 22 for the male. The larger size of catheter produces a deeper anæsthesia. At points 23 cm. and 26 cm. from the tip of the catheter two marks are made, designed to indicate the point at which the incisor teeth should be when the catheter is inserted. In this case the tip of the catheter will be a short distance above the tracheal bifurcation, the 23 cm. mark being used for females and the 26 cm. for males.

A direct-vision laryngoscope is used for introducing the catheter (Fig. 394).

Technique of using the Intratracheal Method. The patient is prepared in the ordinary way and anæsthetised, preferably by chloroform, to avoid a collection of mucus, which may obstruct the view. Complete relaxation must be produced, otherwise spasm and movement will render passing the laryngoscope very difficult.

With the head in the normal position, neither flexed nor extended, the laryngoscope, held in the left hand, is passed along the base of the tongue in the midline ; applying slight pressure in an upward direction, the epiglottis comes into view and is held forward by the curved end of the laryngoscope tube, which is then passed further down, bringing the cords into direct vision. The catheter is then taken in the right hand and passed through the laryngoscope into the larynx. It is essential that the opening of the larynx should be seen clearly, and that the catheter be seen to pass into the larynx; otherwise it may slip into the œsophagus, when the vapour will be pumped into the stomach, with disastrous results.

As soon as the catheter is seen to enter the larynx, and is at the appropriate distance, as seen by the mark upon it, the laryngoscope is withdrawn and the rubber tube from the gas-oxygen machine is connected on to the end of the catheter.

Towards the end of the operation all ether or chloroform should be turned off so that an insufflation of oxygen only is taking place; by this means, when the operation is completed, the narcosis is light and, the catheter being withdrawn, the cough reflex is present, preventing any mucus, blood, etc., being inhaled.

The danger of too deep a narcosis should be guarded against by, firstly, using a catheter small enough to allow expired air to pass out around it; and, secondly, by seeing that respiratory movements are not entirely abolished.

As an exception to this, an increased pressure in the lungs is often necessary for the surgeon's requirements in thoracic surgery.

A larger-sized catheter should be used and the pressure increased; by this means the pleural surface will be brought up to the chest wall and respiratory movements temporarily abolished. It must be remembered that a profound depth of anæsthesia is produced, and so the length of duration of this condition should be as short as possible.

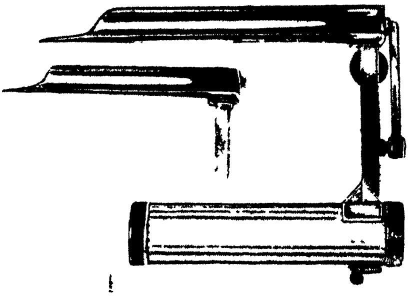


Fig. 394. Magill laryngoscope with semi-proximal illumination used for introducing the catheter into the trachea.

Nasal Intubation. In cases of operations inside the mouth it may be convenient to pass the intratracheal tube *viâ* the nose and nasopharynx. A curved tube of firm rubber is lubricated and passed into the nostril with the concavity of the curve forwards. As the tube is pushed in and approaches the cords, the breath-sounds will be heard.

The tube is then passed forwards at each inspiration and if in correct position will slip in between the open cords, and regular breathing sounds will be heard and felt at the mouth of the tube.

If the breath sounds are not clearly heard, indicating that the tube is not lying correctly between the cords, it should be partially withdrawn and the laryngoscope used to see the tube end, which can then be guided through the cords by direct vision with the aid of Magill's forceps in the mouth. The nasal end of the tube is then connected on to the angle-piece and so to the apparatus (Fig. 393).

Ether per rectum. The anæsthetic effect of ether may be produced by its absorption from the rectum, and this method is found useful in some cases of operation about the face, neck, mouth or tongue. The method has the advantages that a small quantity of ether only is required and the after-effects are slight; also that the anæsthetist does not work at the site of operation. The patient does not undergo the ordeal of the preliminary inhalation, but passes off into a gradual deep sleep, this being very beneficial to the nervous, apprehensive type of patient.

Technique. The night before operation the patient is given 1 ounce of castor oil ; in the morning a soap and water enema is given. One and three-quarter hours before the operation a hypodermic injection of morphia, gr. $\frac{1}{4}$, and atropine, gr. $\frac{1}{100}$, is given.

One hour before the operation a mixture of:

Chloretone	grs. xv
Ether	ʒiv
Olive oil	ʒiv

is made and passed slowly into the rectum. After this the room should be darkened and the patient kept in absolute quiet, the ears being plugged with cotton-wool.

Half an hour before the operation a further administration per rectum of:

Ether	℥vi
Olive oil	℥ii

is given to an adult, the rectal tube being left in situ with a spigot or clip applied to prevent leakage through the tube. The patient is then carefully lifted on to the table and the operation proceeded with.

If narcosis is too deep a little of the ether may be allowed to run out by removing the spigot.

At the termination of the operation all the mixture is allowed to run out, the rectum is well washed out with warm water, 3 ounces of olive oil are allowed to run in and the tube removed.

The above doses are estimated for an adult, the working average being at 1 ounce of the mixture per 20 lb. of body weight, with a maximum dose of 8 ounces.

Preliminary Medication and Basal Hypnotics. To allay the fears and apprehension of a patient about to receive an anæsthetic, various drugs are given with the purpose of producing amnesia or unconsciousness whilst the patient is in bed, and some time before the administration of the anæsthetic commences.

The advantages of this form of premedication are :—

1. The patient is unconscious before being brought to the theatre.
2. A very small quantity of anæsthetic is required to maintain surgical anæsthesia.
3. Unpleasant after-effects are abolished or minimised.
4. The action produces a deep sleep for some time after the operation.

A. **Paraldehyde** per rectum is especially useful in children with well-marked nervousness and excitability. It is often used for adults in cases in which avertin is contra-indicated. The maximum dose should not exceed 10 drachms of paraldehyde.

Preparation. A purgative is given twenty-four hours before the time of operation, or the night before operation an enema is given. After this a light meal may be allowed. One hour before the operation the paraldehyde is administered and half an hour before operation an injection of atropine is given.

Dosage. Fresh paraldehyde to the amount of 1 drachm to each stone of body weight is mixed up and well shaken with warm saline, 10 drachms for each drachm of paraldehyde. The mixture is then run slowly into the rectum. In place of saline, olive oil may be used as a solvent, ½ oz. of oil being used for each drachm of paraldehyde.

After the administration the patient is kept strictly quiet in a darkened room, and in a short time a deep natural sleep is produced, while the odour of the drug can be detected in the breath. The patient will be quite unconscious of the hypodermic needle puncture and will be spared also the distressing apprehension during the removal to the theatre and on to the operating table.

Before the operation is commenced gas and oxygen or ether is administered in the ordinary way, and in a short time surgical anæsthesia is produced without disturbance or excitement; the anæsthetic is continued during the operation, but very little ether is usually sufficient to maintain anæsthesia. After operation the rectum should be washed out with warm water when the patient is back in bed. The effect of the paraldehyde will last for from two to twelve hours after operation, thus helping to tide over the period of post-operative shock.

It is as well when administering the drug to keep the patient ignorant of its purpose, or of the effect that will be produced, and on recovering from the sleep several hours after operation, the patient often will express delight that the operation is concluded without having been conscious of any untoward incidents.

B. **Avertin** or **Brometrol** (tribromethyl alcohol) per rectum is used as a basal anæsthetic as a preliminary to the administration of an inhalation anæsthetic, of which a minimal quantity will then be necessary to produce full anæsthesia.

Its effects are similar to those of paraldehyde; it is odourless, but its narcotic action is more profound and so the dose margin of safety is more limited.

Preparation. The patient should be prepared in the same manner as described above for the paraldehyde administration.

An injection of atropine, gr. $\frac{1}{100}$, and morphia, gr. ⅙, should be given before the rectal injection, though some prefer to omit the sedative. From half to three-quarters of an hour before the operation the avertin is injected per rectum.

Dosage. Avertin is supplied in liquid form, held in solution by amyline hydrate, 1 c.c. of the liquid containing 1 gramme of avertin.

The average dose is reckoned as 0·1 gramme per kilogramme of body-weight of the patient.

To the required quantity of avertin fluid is added warmed distilled water to make a 2½ per cent. solution; this mixture is then shaken thoroughly for several minutes and kept at a temperature not exceeding 40° C. Before injecting the solution it must be tested by adding 2 drops of a 1 : 1,000 Congo-red solution to 5 c.c. of the avertin solution, when a bright red-orange colour should remain. A blue colour indicates the presence of decomposition products and such a solution should not be used.

The avertin fluid is now injected slowly by a soft rubber tube passed about 4 inches into the rectum. The anæsthetist should be present when the injection is made to observe the results and guard against an overdose. Although 0·1 gramme per kilogramme of body-weight is regarded as a safe dose, the susceptibility of patients varies with the general condition.

The patient passes into a state resembling deep sleep, the respirations become quiet, shallow, and slightly slower than normal, with a slight fall of blood pressure. Unconsciousness remains for from three to four hours, Avertin is excreted by the kidneys, and its use is contra-indicated in cases with renal disease.

C. **Barbiturates.** Many of the compounds of barbituric acid are used as basal hypnotics, being administered by mouth, by rectum or intravenously. Of these, the most commonly employed are :—

(*a*) Nembutal.
(*b*) Sodium amytal.
(*c*) Pernocton.
(*d*) Evipan.
(*e*) Pentothal.

(*a*) **Nembutal** is supplied in powder form in capsules containing 1½ grains each for administration by mouth or by rectum, and in ampoules containing 7½ grains each, to be dissolved in distilled water for intravenous administration.

For the oral or rectal route one capsule is given the night before the operation, and one or two capsules given one hour before operation. For children, suppositories containing appropriate doses are especially useful.

If the intravenous route is selected, 7½ grains are dissolved in sterilised distilled water, 10 c.c., and the solution is slowly injected into a vein at the rate of 1 c.c. per minute.

The injection is stopped as soon as the patient falls asleep, the average dose in the adult being between 3 and 6 grains ; the dose should never exceed 7½ grains.

(*b*) **Sodium amytal** is less toxic than nembutal, and doses of from 7½ to 15 grains are used.

The effect usually lasts longer than that of the smaller dose of nembutal, and for this reason it has been found useful in cases of difficult labour.

(*c*) **Pernocton** is supplied in ampoules as a 10 per cent. aqueous solution, and so is most suitable for intravenous administration.

(*d*) **Evipan** is a powder supplied in ampoules containing 1 gramme. A solution for intravenous injection is made by dissolving the powder in 10 c.c. of distilled water just before use.

The solution is injected into the vein slowly (fifteen seconds per c.c.), until the patient falls asleep. In this way it may be used as a preliminary to an inhalation anæsthetic. In some cases muscular spasms occur during induction, which may cause movements of the arm and lead to shifting the position of the needle out of the vein. It is advisable therefore to strap the arm to a metal back splint and to hold the needle firmly in position. The spasms subside as the injection proceeds. The injection may be continued until a deeper narcosis and relaxation of the muscles and dropping back of the jaw are produced. During recovery, varying degrees of excitement are noted in some patients ; these are not usually of long duration, being followed by a short period of calm sleep and recovery.

By this means minor operations may be performed under evipan alone. The dose is gauged by the effect on the patient during injection, from 4 to 5 c.c. usually producing sleep, and 8 to 10 c.c. producing anæsthesia lasting from fifteen to twenty minutes.

(*e*) **Pentothal** is of similar formula, though with a more powerful action than evipan.

It is supplied as a powder in capsules containing 1 gramme, which is dissolved in 20 c.c. of distilled water for intravenous use.

The 5 per cent. solution is clear and slightly yellow coloured.

The intravenous injection is made very slowly whilst the patient is carefully watched.

During injection, at the rate of 1 c.c. per minute after the first c.c., the patient usually becomes sleepy, with 2 c.c. he falls asleep and with 3 c.c. a deep sleep is produced in the majority of cases. At this stage a depression of respiration is noticed, more marked than with that of evipan. Care should be taken to prevent falling back of the jaw and to maintain a free airway. Induction by this method is smooth and usually without excitement. Recovery after small doses takes place quickly and with no after-effects. Injection should cease if signs of respiratory depression become marked.

Dosage. The estimation of the dosage of the barbiturates is difficult, and it has been found that the effects produced are not uniform.

They should not be used as a routine, but only in selected types of cases. Their use is contra-indicated in cases of sepsis, and gross renal or hepatic disease.

Experience in their use is essential for safety. It is only intended here to acquaint the reader with the broad outlines and technique of the use of those drugs, and further study of the literature on the subject is recommended.

The use of basal narcotics may produce, either from idiosyncrasy or overdose, severe respiratory and cardiac depression.

As an antidote, *Coramine* should be given. In slight cases 2 to 3 c.c. intramuscularly or in severe cases up to 5 c.c. intravenously. In this connection it should be stressed that morphia or similar drugs should be withheld for some considerable time; in the case of barbiturates at least one hour, and with avertin, four to five hours after administration.

Thrombosis in the vein has been reported in some cases after the use of intravenous barbiturates. It should not be injected into a vein showing signs of varicosity.

CHLOROFORM

Chloroform is the anæsthetic of choice in certain types of cases, such as the following:—

1. In affections of the lungs and air passages.
2. In cases with high blood pressure or arterial disease.
3. Operations on the eye requiring a general anæsthetic.
4. When the use of the actual cautery is employed.
5. In tropical climates where ether is impracticable.

Chloroform should be avoided or used with extreme caution in cases of:—

1. Asthenia with low blood pressure.
2. Young children.
3. The muscular and alcoholic subject.
4. Toxæmia.
5. Cyanosis due to some obstruction to respiration.

Preparation of the patient is the same as described previously; the administration of atropine, gr. $\frac{1}{100}$, is important when using chloroform as counteracting the action of cardiac vagal inhibition, which is more likely to occur with chloroform than with ether (p. 771).

Method of Administration. The most simple and convenient method of administering chloroform is by the open method on a lint mask, such as the Schimmelbusch. Chloroform, or mixtures containing chloroform, should never be given from a closed inhaler, a free supply of air with the vapour being an essential to safety.

A pad of gamgee tissue with a hole for the mouth and nose is used, as described previously, and the mask held in the left hand away from the face. The chloroform drop bottle (Fig. 388, C) is held in the right hand, holding the index finger over the stopper. With a few words of encouragement the patient is instructed to breathe quietly and naturally, the head being turned to one side.

To commence with, a few drops of chloroform are allowed to fall on the mask, and at regular intervals drops are added; at the same time the mask is brought gradually nearer the face until it is allowed to rest about ½ inch from the pad of gamgee tissue, and is held in position by the left hand, the little finger of which is used to hold the lower jaw forward.

Continuing with the regular addition of a few drops of chloroform, the strength of the vapour inhaled is gradually and slowly increased until anæsthesia is produced; and when once anæsthesia is produced a smaller quantity and more dilute vapour is required to maintain sufficient anæsthesia throughout the operation. Throughout the administration a free admixture of air must be allowed for.

Phenomena of Chloroform Anæsthesia. For purposes of description, the progress of narcosis is usually divided into five stages, though these different stages merge one into the other in succession.

The First Stage. After two or three inspirations of the dilute vapour there is produced an acceleration in the pulse rate, which is at first fuller; the patient experiences a fulness in the head and buzzing in the ears. The fulness of the pulse is soon replaced by a weakened and slower pulse. The respirations increase in frequency. The eyes move and the pupils are slightly dilated and react to light.

The Second Stage is the *stage of excitement,* in which the patient may talk or shout, and later may struggle or fight.

Spasms of the respiratory muscles occur, with holding of the breath, followed by an increase in the respiratory rate. The pulse rate is increased, but later becomes slower and weaker, as fall of blood pressure occurs. During the excitement the pupils enlarge, but react to light, the conjunctival and corneal reflexes being present.

The Third Stage. All movements cease, the patient lies quiet, and the muscles gradually relax. The respirations become regular and slightly shallower than normal. The pulse rate becomes regular and normal, though at low pressure. The eyes become fixed and the pupil contracts and is inactive to light. The conjunctival reflex is now lost; the corneal reflex usually can be elicited. At the end of this stage surgical anæsthesia is produced.

The Fourth Stage. In this stage the medullary centres commence to be affected seriously, and therefore the fourth stage should be regarded as an indication of overdose. The respirations become stertorous, irregular, and more shallow. The pulse rate becomes more rapid and increasingly feeble as the blood pressure falls. The eyes are fixed and open, the pupil becomes dilated. The corneal reflex is abolished.

The Fifth Stage ushers in the complete failure of the respiratory and cardiac centres. The respiration becomes more and more shallow until there is complete cessation followed by cardiac failure.

Conducting the Anæsthesia. When the stage of surgical anæsthesia has been reached and maintained for from two to three minutes, as evidenced by—

(*a*) The regular respiratory rhythm,
(*b*) The contracted pupil,
(*c*) The muscular relaxation,

the regular addition of drops on the mask is continued at the same rate and the operation may be commenced.

After the operation has proceeded a few minutes, it is advisable gradually to reduce the amount of chloroform given, and it will be found that a definite minimum can be reached sufficient to maintain satisfactory relaxation for the needs of the operation. Careful attention should be paid to the respiratory rhythm; any alteration from the regular sonorous breathing should immediately warn the anæsthetist of danger; and investigation of the pulse, the size of the pupil, and the colour will indicate whether it is the result of overdose or of returning consciousness.

It must be remembered that the absorption of chloroform by the lungs is very rapid, and its toxic action on the heart is correspondingly rapid. For this reason, when using chloroform as compared with ether, it is of the utmost importance that the regular respiratory rhythm should be maintained, for though, with the latter, slow, shallow and even a short cessation of respiration can be recovered from quickly, with chloroform, with its rapid action, the heart muscle is soon seriously affected.

The necessity for careful watching of the patient during chloroform administration and the thin dividing line between safety and the danger of overdose cannot be too strongly emphasised. If it is found that the respirations are becoming irregular, the mask should be removed and an examination of the pupil made.

If the pupil is found to be dilating and the light reaction lost, the indication is a commencement of an overdose; the administration should be stopped and air or oxygen given until the pupil contracts, and respirations become again regular. The mask should then be replaced and the regular administration of drops recommenced.

The size of the pupil as a sign should be used in conjunction with other signs as an indication of the condition of the patient.

If too little anæsthetic is administered the pupil will dilate, but will react to light and the conjunctival and corneal reflexes become brisk; with these signs will be seen the swallowing movements and even retching movements preparatory to vomiting. These show an insufficient anæsthesia, and an increase of vapour is required.

The dilated pupil of *overdose* will be accompanied by loss of light reaction, irregular shallow respirations, a thin, rapid pulse, pallor of the skin and extreme flaccidity of the muscles.

The fact that an overdose may be produced without an excess of chloroform being administered must be realised. This may be produced by some obstruction occurring in the respiratory tract. The obstruction causes a block to the outlet of carbon dioxide, and so an increase in the carbon dioxide content of the blood in which the toxicity of the chloroform is thereby increased. As soon as the obstruction to the airway, such as may be caused by the tongue falling back, is removed, and oxygen administered, sufficient aeration of the blood is restored and the chloroform administration may be recommenced.

It is, therefore, highly important that a patent airway should be maintained, and in this a Hewitt's airtube will be found a most useful aid.

The recovery from chloroform anæsthesia is more rapid than is the case with ether, due chiefly to the fact that a smaller quantity of the drug is used. The rapidity of recovery varies with the amount of chloroform inhaled, and so with the length of the operation.

Signs of syncope may occur prior to the act of vomiting, the patient becoming cold and clammy with a rapid, thin pulse; this usually passes off after vomiting has occurred, when the patient often passes into a natural sleep. Signs of syncope may occur if the patient should sit up quickly or be moved unduly about the bed.

The same precautions as described on p. 775 should be taken during the recovery, with special care for signs of syncope.

Difficulties and Dangers during Chloroform Anæsthesia. (1) During induction *violent struggling*, especially in the strong muscular or alcoholic type of patient, may give trouble.

The movements should be controlled as gently as possible, and the mask removed until quiet and regular breathing is restored. During this excitement period it is common for the breath to be held for some time, followed by a deep inspiration. If the mask is held close to the face at this time a sudden large dose of vapour may be inhaled with fatal results.

(2) *Cyanosis and failure of respiration,* accompanied by cardiac failure, may be due to:—

(i.) Obstruction of the airway from—
  (*a*) Falling back of the tongue.
  (*b*) Foreign bodies.
  (*c*) Inflammatory conditions around the neck or in the mouth (e.g., enlarged tonsils, etc.).
  (*d*) Laryngeal spasm.
(ii.) Overdose.

The fact that the respiratory exchange of gases is interfered with by obstruction to the airway will cause an overdose, as explained above.

The mask should be removed immediately, any cause of obstruction in the airway removed, a Hewitt's airway inserted, and ogygen administered; when the colour has returned to normal and respirations have become regular the administration is continued slowly. If these measures *fail tracheotomy should be performed at once.*

If the cause is due to an overdose with a clear airway the mask is removed, the head lowered, the tongue held forward and artificial respiration, with oxygen administered, should be begun at once. A towel wrung out in hot water should be applied to the head. Coramine intravenously (1 to 2 c.c.) is a useful cardiac stimulant.

If these measures fail after a short time direct cardiac massage must be resorted to. The injection of 1 c.c. of 1 : 1000 adrenalin solution directly into the heart may be of use in restoring the cardiac rhythm.

For this a cardiac puncture needle is used and passed into the chest wall to a depth of about 3½ inches at the upper edge of the fifth rib, close to the left border of the sternum, and directed slightly towards the midline.

(3) *Signs of syncope* from surgical shock occur when insufficient anæsthesia is maintained.

It may be well here to repeat the signs of overdose; they are, alterations in respiratory rhythm, rapid, thin pulse, pallor and clammy skin, widely dilated and inactive pupils, extreme muscular relaxation; and compare these with the signs occurring from syncope due to insufficient anæsthesia, namely, alteration in respiratory rhythm, rapid, thin pulse, pallor and clammy skin. The pupil is widely dilated but active, with presence of corneal reflex, which is brisk. The flaccidity of the muscles is not complete. These signs are accompanied by swallowing movements, and even retching.

To overcome the difficulty occurring from insufficient anæsthesia it is advisable that all surgical manipulation should cease and a gradually increasing supply of chloroform be administered until sufficient depth of anæsthesia is reached.

After-effects of Chloroform Inhalation. *Vomiting.* This varies with different patients, some being more affected by chloroform than by ether, and others less so. On the whole, chloroform may be said to cause less after-sickness than is the case with ether.

Pulmonary complications are not so common after chloroform as after ether, it not being so irritant to the mucous membrane and not causing such excessive mucous secretion.

Collapse and syncope may be due to a prolonged administration of chloroform from toxic effects on the heart. Again, it may be due to incomplete anæsthesia, the signs being more marked as the patient is recovering and "coming round." The shock may be due to the severity of the operation alone.

The treatment consists in the general line of treatment for shock and collapse as described on p. 52.

Intravenous infusions are inadvisable owing to the enfeebled heart action.

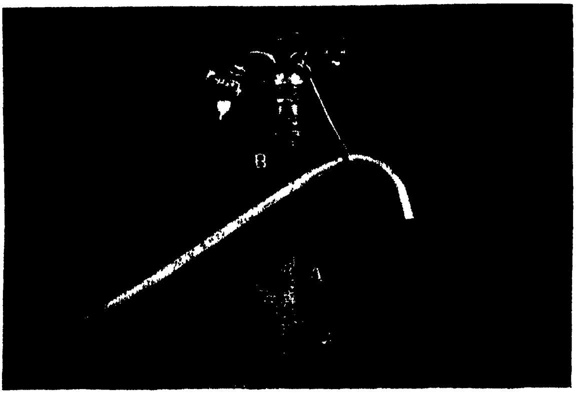


FIG. 395. Dudley Buxton's modification of Junker's inhaler, in which the long tube A is ensheathed in its upper part by the short exit tube B, thus preventing liquid chloroform entering the tubes if the bottle is tilted.

Acidosis (Delayed chloroform poisoning). This is a rare condition occurring from two to eight days after chloroform inhalation, and following severe vomiting. After a period of restlessness a state of apathy is followed by coma. The urine is diminished in quantity and becomes charged with acetone and diacetic acid. The coma gradually deepens and death from respiratory and cardiac failure occurs. This condition occurs more commonly in children than in adults, but how far it is due to chloroform toxæmia has not been definitely proved.

Treatment is of little avail; that holding out the most hope of success consists in washing out the stomach with a solution of sodium bicarbonate and administering glucose and saline per rectum.

Inhalers for Administering Chloroform Vapour. 1. *Shipway's apparatus* is a convenient method for operations about the face, nose and mouth, and is used as described on p. 780, turning the valve lever so that the air or oxygen is passed through the chloroform bottle.

This apparatus should not be used if the actual cautery is in use, unless it is seen beforehand that all trace of ether has been removed from the ether bottle.

2. *Junker's Inhaler.* This is a convenient and portable apparatus for administering chloroform vapour alone. It consists of a small, long bottle into which are poured about 4 to 6 drachms of chloroform; through the screw stopper pass two metal tubes, one of which (A) passes nearly the whole length of the bottle and dips into the liquid, the second (B) passes through the stopper only.

The longer tube is connected outside with a hand-bellows or oxygen cylinder, and through this tube air or oxygen is bubbled into the chloroform, the vapour then passing through the shorter tube, to which is connected a length of rubber tube through which the vapour reaches the mouth or enters through nasal catheters, to be inspired by the patient.

For convenience a metal hook is fixed to the bottle, by means of which the bottle can be fixed to the anæsthetist's gown.

The following precautions should be taken in using this inhaler:—

(1) It should be tested before use; if the bellows are fixed to the wrong tube liquid chloroform will be pumped through, and fatal accidents have occurred in this manner.
(2) The bottle should not contain more than 8 drachms of chloroform.
(3) The bottle must always be held in the upright position.

MIXTURES

The administration of a mixture of chloroform and ether is frequently used with a view to the one drug counteracting, to a certain extent, the harmful effects of the other drug.

Thus it is presumed that the depressant effect of the chloroform is counteracted by the stimulation produced by the ether, and the irritant action on the respiratory tract brought about by ether inhalation is avoided by its dilution with the less irritant narcotic, chloroform. It has been shown, however, that the degree and rate of evaporation of the two liquids are not proportionate with the amount of each drug used, so that the actual strength of chloroform vapour inhaled is unknown.

It is probable that in administration the actual induction of narcosis is brought about by the chloroform alone, and that, with the free admittance of air, which is essential to safety, the small quantity of ether vapour inhaled acts merely as an exhilarant.

The chloroform and ether mixtures used are of varying proportions, those most commonly in use being:—

1.	Chloroform . . .	2 parts.
	Ether	3 parts.
2.	Chloroform . . .	1 part.
	Ether	7 parts.
3.	Chloroform . . .	1 part.
	Ether	32 parts.

Another mixture which was formerly in common use included a proportion of alcohol added to the chloroform-ether mixture, viz.:—

Chloroform . . .	1 part.
Ether . . .	2 parts.
Absolute alcohol . .	3 parts.

This, which is known as the A.C.E. mixture, is not extensively used now, as its advantages over the C.E. mixture are not evident, and the after-effects of the alcohol undoubtedly are more unpleasant than those occurring after the use of C.E. alone.

The preparation of the patient, and the method and principles of conducting the administration, should be on the same lines as those described under the administration of chloroform.

On no account should any mixtures containing chloroform be used in a closed apparatus, such as the Clover, a plentiful admission of air being imperative in all cases.

ETHYL-CHLORIDE

Ethyl-chloride is extensively used for the production of a rapid, short anæsthesia.

The anæsthesia produced is sufficient only for a short operation, such as the removal of a tooth, the opening of an abscess, etc.

The colourless liquid is supplied in graduated glass tubes fitted with a spring nozzle, which, when opened, delivers a fine spray. It possesses advantages over nitrous oxide gas in its rapid action and its portability; on the other hand, in its degree of safety as an anæsthetic, it is not comparable with that of nitrous oxide.

Preparation of the Patient. The same precautions as to preparation should be taken as in the case of ether or chloroform. The patient may be anæsthetised in the sitting position if the type of operation requires it.

Methods of Administration. (A) *The Closed Method.* A simple and efficient apparatus for this method consists of an ordinary rubber bag fitted with a metal collar at the neck, on to which is fitted the facepiece. In the metal collar is a small hole through which the ethyl-chloride may be sprayed into the bag. As an alternative to this and to annul the risk of the liquid being sprayed towards the facepiece, a small glass tube can be fitted to the lower end of the bag. Into this tube is sprayed the requisite amount of the anæsthetic, which can then be tipped up so that the liquid enters the bag and vaporises.

The facepiece and the bag should be washed out thoroughly with ether soap and water after each administration.

Dosage. For an adult the dose should average 5 c.c., for children above five years of age 3 to 4 c.c.

The facepiece is held firmly against the face to prevent leakage of air around it, and after the first breath the liquid is sprayed into the bag or the small tube tipped slowly up so that the liquid reaches the bag and the vapour is inspired.

(B) *The Open Method.* Ethyl-chloride may be administered by means of a wire mask fitted with two or three layers of lint.

The liquid is sprayed on to the mask, which is then covered over with a towel or thick piece of blanketing, otherwise freezing is very likely to occur and vaporisation unsatisfactory. A larger dose is required by this method, an adult usually needing from 8 to 10 c.c. This method may be used as a preliminary to ether administration in the place of nitrous oxide.

Phenomena of Ethyl-Chloride Inhalation. At the first inspiration of the vapour there is likely to be some coughing and struggling, and perhaps holding of the breath, but when the vapour is once absorbed breathing becomes more rapid, regular and fuller; for this reason it is advisable, when using the closed method, to admit at first only half the dose, and when the respirations have become regular then to admit the remainder.

Very rapidly, with the rhythmic respirations, the skin becomes flushed and of a pink colour, the pupils slightly dilated, the eyes often remaining open and the eyeballs fixed. At the same time the pulse rate increases to a rapid rate. After a few more breaths the breathing becomes stertorous, and a deep narcosis is produced; at this point the facepiece should be removed and the operation commenced.

It is important to remember that after the anæsthetic is withdrawn, for the first few breaths the narcosis deepens, and for this reason it is advisable to remove the apparatus as soon as stertor appears. This phenomenon is especially marked in children. The anæsthesia produced will last for from two to three minutes.

The recovery, as with the induction, is very rapid, the patient remaining dazed for a few minutes, followed by complete recovery of consciousness. Nausea and vomiting are frequently observed on recovery, but do not usually persist.

Difficulties and Dangers during Administration. 1. *Spasm of the respiratory muscles and glottis* is likely to occur during induction, and for this reason a dental prop should always be inserted before commencing the administration, otherwise clenching of the jaw muscles, increasing the obstruction to air intake, may have serious consequences. The anæsthetic should be withdrawn and the tongue drawn out until the spasm has passed.

2. *Obstruction to Respiration.* It must be remembered that the degree of narcosis obtained is profound, and great care should be taken that mucus, blood, etc., is not allowed to collect in the mouth and pass into the air passages.

3. *Faintness and syncope* are likely to occur immediately after the administration. The patient should be placed in the recumbent position and stimulants given.

4. *Overdose* will produce a sudden change in respiratory rhythm, this becoming rapid and shallow, followed by cyanosis, pallor and a failing pulse.

The anæsthetic should be withdrawn, the patient placed in the recumbent position, the airway cleared and the tongue be drawn out. In the event of respiratory cessation, artificial respiration must be performed. If circulatory failure follows, intracardiac injection of adrenalin (p. 789), or even cardiac massage, must be resorted to.

Contra-indications. Ethyl-chloride should not be used in cases showing any respiratory embarrassment, whether due to obstruction of the air passages or to lung disease. It is contra-indicated in cases of severe myocarditis with weak cardiac action. Alcoholic patients are likely to struggle and become violent under ethyl-chloride, and the duration of the anæsthesia is much shortened.

Young children take this anæsthetic usually very well, and there is no doubt, in this instance, if administered by an expert accustomed to its use, it possesses great advantages over nitrous oxide, which young children do not take satisfactorily. It is, therefore, most suited for children from one week old and upwards requiring short operations. In all cases, however, owing to its rapid action and the depth of narcosis produced, great care and experience is essential to maintain safety.

LOCAL AND REGIONAL ANÆSTHESIA

The abolition of painful stimuli in a specified area may be obtained by:—

(A) **Local Anæsthesia**:—

I. By application of cold.

II. By direct application of a drug to the skin or mucous membrane.

III. By hypodermic injection and infiltration of a solution of the drug.

(B) **Regional Anæsthesia** :—

IV. By injection of a solution of the drug :—

(*a*) Into the spinal canal (*spinal anæsthesia*).

(*b*) Around the sensory nerves near the spinal column (*paravertebral anæsthesia*).

(*c*) Around the semilunar nerve ganglia (*splanchnic anæsthesia*).

(*d*) Around the sacral and coccygeal nerves (*parasacral anæsthesia*).

(A) **Local Anæsthesia.** I. Analgesia of a small area of skin may be produced by *freezing*, by means of directing the spray of ethyl-chloride on to the surface. The method is unsatisfactory in that it is liable to produce sloughing of the skin if prolonged, and much pain is often experienced after the analgesic effect has passed off.

Ether spray is sometimes used in place of that of ethyl-chloride.

For the extraction of a painful tooth, previous spraying of the gums lessens the pain during application of the forceps.

II. Certain drugs in solution applied to mucous surfaces render them temporarily insensitive to pain. For this purpose *cocaine* is extensively employed in *rhinolaryngological* examinations and operations. A solution of 5 to 10 per cent. is used to apply to the nasal mucous membrane, by means of a pledget of wool soaked in the solution ; for the nasopharynx and larynx a 4 per cent. solution is applied by means of a spray.

In operation cases an addition of a solution of 1 : 1000 adrenalin is advisable ; it is said to prolong the action of the cocaine, and is of value as an hæmostatic.

It should be borne in mind that in some patients an idiosyncrasy to cocaine exists, and also that the toxic effects of cocaine are very liable to be produced if used in the bladder or urethra. In these cases novocaine should be used in place of cocaine.

In *ophthalmic work* cocaine is most satisfactory in its action.

Drops of a solution of 2 to 4 per cent. cocaine are instilled on to the conjunctiva at varying intervals, and after two or three applications the eye is rendered insensitive and the operation proceeded with. Further drops may be added if the operation is prolonged.

Thin lamellæ of the drug may be alternatively employed, being placed on to the conjunctiva at the corner of the eye, where it is dissolved in the lacrymal fluid.

III. To anæsthetise an area by means of *hypodermic injection* cocaine has been discarded for novocaine.

Novocaine is seven times less toxic than cocaine, it may be sterilised by boiling, it is non-irritant and may be given in large quantities in a ½, 1 or 2 per cent. solution. Adrenalin 1 : 1000 solution may be added, using 10 minims in 100 c.c. of novocaine in sterile saline.

The method is used extensively for the removal of small tumours of the skin, e.g., sebaceous cysts, small papillomata, etc. The solution is best injected by means of a sterilised Record syringe, using fine and sharp needles. The skin of the area is cleaned and painted with an antiseptic, such as iodine or picric acid.

No special preparation of the patient is needed beforehand.

Infiltration Method. By this method large quantities of a dilute (1 per cent.)

solution of novocaine are injected hypodermically and also into the deeper tissues.

A large glass syringe holding 20 c.c. fitted with a fine, sharp-pointed needle is best used for this purpose. Care should be taken to avoid puncturing a vessel, as novocaine injected directly into a vessel may produce respiratory failure; for this reason a fine-bore needle should be used and aspiration practised before each injection into the deeper tissues.

The infiltration method is conveniently used in cases of exophthalmic goitre (see Vol. II., Chapter X.), where often a general anæsthesia is inadvisable, owing to the toxic condition of the patient.

For this purpose an isotonic solution is used and prepared as follows :—

℞ Novocaine . . . grs. vi.
Sodium chloride . . grs. xv, dissolved in 200 c.c. of water and sterilised by boiling.

When cold, adrenalin hydrochloride (1 : 1,000) ♏xv are added.

Half an hour before operation the subcutaneous tissues are infiltrated, and more of the fluid may be injected during the operation.

It is advisable to give a hypodermic injection of morphia, gr. $\frac{1}{6}$, with hyoscine, gr. $\frac{1}{150}$, one and a half hours before and again three-quarters of an hour before the operation.

It must be borne in mind that the psychic effect of an operation during consciousness in this class of patient is very real, and may seriously lessen the chances of the patient combating the shock of operation. For this reason it is common to combine this method with light narcosis by the use of gas and oxygen or a small quantity of ether. Perhaps the most suitable method of all for this type of case, as mentioned on page 783, is the rectal paraldehyde administration combined with light narcosis.

In abdominal surgery infiltration of the abdominal wall, the rectus sheaths, the mesentery, etc., eliminates muscular rigidity, whilst unconsciousness is obtained by administering nitrous oxide and oxygen, or the minimum amount of ether by inhalation.

The advantages of this method, in that the patient receives the minimum of narcotic, are somewhat counteracted by the increase in the time taken by the infiltration and that any pulling and dragging on the tissues or viscera is not borne unless extensive regional anæsthesia is added, which again adds to the time the patient is on the table.

(B) **Regional Anæsthesia.** IV. By means of introducing the anæsthetic solution around nerves supplying a definite region, the sensation of pain in that region is abolished.

These methods may be regarded as an extension of Crile's method of *anoci-association* whereby shock is diminished :—

(*a*) By blocking the central nervous system from the area of operation.

(*b*) By diminishing the amount of narcotic drug used.

The anæsthetic may be introduced :—

(*a*) Into the spinal canal—**Spinal anæsthesia.**

By this method the anæsthetic fluid is introduced into the subdural space where it acts upon the roots of the spinal nerves and the rami communicantes blocking nerve conduction to the region innervated thereby.

Drugs used. (*a*) *Solutions heavier than Cerebro-spinal Fluid.*

(1) A drug commonly used and giving satisfactory results is *Barker's solution*, consisting of 5 per cent. stovaine solution with 5 per cent. glucose

solution, the dose being from 1 to 1·5 c.c. of the mixture for an adult, according to the build and weight of the patient.

(2) Stovaine dissolved in saline in a 10 per cent. solution (stovaine-billon) supplied sterile in ampoules containing 1 c.c., the average dose being from 0·4 to 0·5 c.c.

(3) Duracaine heavy solution, being a 10 per cent. solution of planocaine (novocaine) containing gliadin and glycerine.

(4) Percaine heavy solution, 1 : 200, supplied in ampoules, each containing 2·3 c.c.

It is used chiefly for low spinal anæsthesia, from 1 to 1·5 c.c. being injected in the third or fourth lumbar interspace.

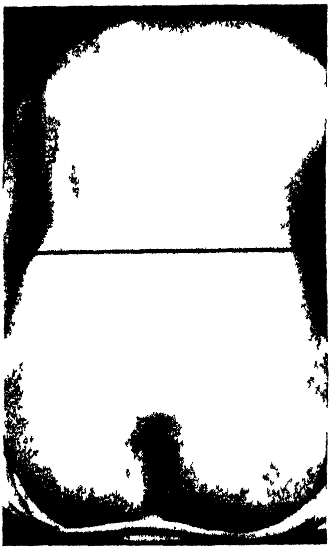


FIG. 396 Position of the patient for spinal injection of heavy solution. The line is drawn at the level of the upper borders of the iliac crests.

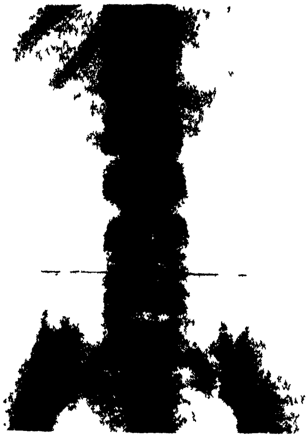


FIG 397 An X-ray photograph of the lumbar vertebræ, showing the landmarks for the site of the spinal injection. The line joining the upper border of the iliac crests crosses the spine of the fourth lumbar vertebræ.

Instruments. The best type of syringe to use for the injection is Barker's syringe, which consists of a glass barrel marked to measure c.c.'s. The barrel is fitted with a detachable metal collar and plunger. The hollow needles, about 3 to 3½ inches long, have their points obtusely bevelled; they are fitted with stylets bevelled in the same manner, and having on them a spike fitting into a notch in the shoulder of the needle indicating the side of the bevelling of the needle point. Fitting into the hollow needle is a cannula which, when in place, projects just beyond the point; this ensures that all the fluid will enter into the canal with the needle in position. The syringe should be carefully sterilised by boiling before use.

Preparation of the Patient. No special preparation is needed, but only light food should be given before the operation. A rectal wash should always be given just before operation, as the sphincters become relaxed after the spinal injection.

An injection of morphia, gr. $\frac{1}{6}$ to $\frac{1}{4}$, may be given half an hour before operation.

The spinal injection should be carried out under strict aseptic precautions, and the skin area over the lumbar spines should be cleaned and painted with iodine. During the operation the patient's view of the proceedings should be screened off.

Site of the Injection. The point usually chosen is the space between the spines of the third and fourth lumbar vertebræ; if difficulty is encountered at this point, that between the fourth and fifth or between the second and third lumbar spines may be used.

Technique of the Injection of the Heavy Solution. *Position of the Patient.* The patient should be sitting on the edge of the table with the legs hanging over the side, the thighs being flexed, the head kept in the midline and flexed fully forward. The patient should sit evenly, allowing no lateral deviation of the line of the vertebral spines. Some prefer the patient in the lateral position, with head and thighs fully flexed.

Landmarks for Site of Puncture. The area being repainted with iodine, the edge of a sterile towel is held tautly across the back from the level of the upper borders of the iliac crests; this crosses the spine of the fourth lumbar vertebra, and the site of puncture will be directly above this, i.e., between the third and fourth lumbar vertebræ.

The needle and stylet are held in the right hand, kept in the midline, and pushed firmly forwards, directing them slightly upwards, for a depth of about 1½ inches. It is advisable to warn the patient that he will feel the prick of the needle, and to impress on him the risk of any sudden movement on his part. As the needle is passed the slight resistance during its passage through the interspinous ligaments will be recognised.

The stylet is now withdrawn, and the needle with its cannula is pushed further, when the slight resistance of the dura will be experienced and the spinal fluid will appear in drops, often heralded by a sucking noise.

The total depth to be traversed by the needle varies with the build of the patient, but is usually from 2½ to 2¾ inches.

After about 1 c.c. of the fluid has come away the syringe containing the appropriate quantity of anæsthetic solution is attached and a small quantity of spinal fluid withdrawn into the barrel; then the plunger is pushed slowly in and the anæsthetic fluid injected. The needle and cannula are then withdrawn (a small sterile dressing should be fixed on to the site of puncture) and the patient placed lying on his back, with the head and shoulders slightly raised. The patient is allowed to remain in this position for from five to ten minutes, after which the heavy solution will be fixed and no risk is attached to the lowering of the head or even to the Trendelenburg position. After five to ten minutes, tests of sensation in the lower extremities will indicate that the anæsthetic effect has been produced.

The duration of the action of the drug varies considerably, but averages about three-quarters of an hour to one hour.

Whilst the operation is proceeding the anæsthetist should keep observation on the pulse and note any fall of blood pressure, pallor or faintness. These phenomena commonly occur after the first fifteen or twenty minutes.

There is no doubt that the blood pressure falls considerably, and sometimes to an alarming extent; this may be prevented by lowering the head, giving camphor or ephedrine; or the patient may be given brandy or some other stimulant; the condition usually soon improves (vide p. 790). In all cases on the patient's return to bed, the pillow should be removed and the head and shoulders kept low for some time after the operation.

(*b*) *Solutions Lighter than Cerebro-spinal Fluid.*

When using the light solutions the patient should be in the lateral position, and immediately after the injection the head and shoulders should be kept low for a short time; in other essentials the technique described above should be adhered to.

(1) *Novocaine*, dose 2 to 3 c.c. of a 10 per cent. solution (v. spinocaine, duracaine).

(2) *Spinocaine.* Each cubic centimetre of spinocaine contains novocaine, 100 mg., strychnine sulphate, 1·1 mg., the solvent containing alcohol, 14·5 per cent., sterile water and amylo-prolamin. It is claimed that with this solution large doses of novocaine may be used with safety and the level of anæsthesia controlled by the dose used and extent of admixture of cerebro-spinal fluid during injection.

The dose is from 1 to 3 c.c., into which is aspirated 1 c.c. of cerebro-spinal fluid, aspirating once or twice according to the height of anæsthesia to be reached, the table being tilted to the required degree of Trendelenburg position after the injection.

(3) *Duracaine* light solution is a 10 per cent. solution of planocaine (novocaine) containing gliadin and ethyl alcohol. It is supplied sterile in ampoules of 3 c.c. containing 0·3 gm. of planocaine.

(4) *Percaine*, a derivative of quinoline, as a local anæsthetic, is effective with a long period of action in very small doses.

Used in a solution in normal saline with the addition of 1 : 1,000 adrenalin it produces its effect in dilution of 1 : 2,000.

As a spinal anæsthetic it is used in strength of 1 : 1,500 in 0·5 per cent. saline, having a specific gravity of 1·003, i.e., lower than that of cerebro-spinal fluid. The injection is made in the lateral position, and immediately afterwards the patient is placed in the prone position with a slight Trendelenburg tilt. After five to ten minutes, the patient is turned on his back and the Trendelenburg position maintained during the operation. The dose of the drug used will depend on the level to which anæsthesia is required, and on the length of the spinal column. The long spine requires a larger relative dose than the short spine.

For a caudal block a dose of 6 c.c. of the solution is sufficient, whilst for upper abdominal operations, from 15 to 18 c.c. is required.

Difficulties encountered during Injection. 1. In stout patients the bony landmarks are difficult to identify, and more than one attempt may be necessary before finding the correct space.

2. Patients with chronic osteoarthritis of the spine present difficulties in that the edges of the vertebræ are irregular, and bony outgrowths may be encountered by the needle.

3. If the direction of the needle is not maintained forward in a straight line, the needle will strike bone and the point be blunted.

4. The failure to produce a flow of spinal fluid may be due to—

(*a*) The needle entering the spinal theca at one side instead of in the midline.

(*b*) The lumen of the needle being blocked with a small clot from a punctured vessel.

(*c*) Passing the needle with its stylet too deeply, so that it passes through to the anterior surface.

In all cases of failure it is advisable to withdraw the needle entirely and make a second puncture.

5. When the spinal canal has been injected with the patient in the lateral position, it has been noted occasionally that the anæsthesia is produced in one side only.

Difficulties and Dangers liable to occur after the Injection. (A) *Immediate.* 1. The fall of blood pressure occurring a short time after the injection is accompanied by faintness, with sweating, restlessness and pallor. This usually passes off after the administration of a little brandy or a hypodermic injection of ephedrine, 1 grain.

2. Respiratory embarrassment, air hunger and cyanosis are likely to occur if the anæsthesia reaches a high level, as may occur from a faulty position of the patient, or from overdose.

A puncture should be made to draw off 4 or 5 drachms of cerebro-spinal fluid, after which artificial respiration and stimulants should be applied.

(B) *Remote.* 1. Meningitis due to infection introduced during the injection. This should never occur if proper aseptic precautions have been taken.

2. Nerve lesions affecting chiefly the sixth and eighth nerves producing a temporary ocular paralysis and deafness.

3. Retention of urine and rectal incontinence in rare cases have been known to persist.

4. Headache is frequently observed following spinal anæsthesia; in some cases it is severe and persistent. A pill consisting of—

℞	Acetanilide	grs. ij
	Caffeine citrate	gr. i
	Codeine	gr. ⅛

is usually effective in relieving this.

5. It must be remembered that the anæsthesia in the legs may be still present when the patient is put back to bed, and care must be taken that burns are not produced from hot-water bottles in the bed. Fæces and urine may be passed unconsciously before control returns.

6. Vomiting does occur in many cases, but is slight.

Contra-indications of the Use of Spinal Anæsthesia. 1. Feeble patients with *low blood pressure.* With these cases the additional initial fall of blood pressure, which in some cases is very marked, may produce a condition of cardiac failure. In general, a spinal anæsthetic should not be given to the very ill patient.

2. *Pyæmia.* The danger of meningitis following spinal puncture in this condition contra-indicates this method.

3. *In very nervous and highly-strung patients,* sudden movements during the puncture may render this method a dangerous or perhaps impossible procedure.

4. *Chronic osteoarthritis of the spine* with bony irregularities render it very difficult to puncture the dural space.

Combined General and Spinal Anæsthesia. At the time when the method of spinal anæsthesia was introduced it was common to consider that many patients were not in a fit state to take a general anæsthetic. Since then the increased safety of the methods whereby inhalation anæsthetics may be given have brought to a minimum the type of case which formerly would have been regarded as unsuitable. Again, the fear and apprehension of the patient in being rendered unconscious is a phenomenon which one rarely encounters in these days. It is, therefore, the common practice now to combine with spinal anæsthesia a light degree of narcosis by administering a small quantity of anæsthetic by inhalation.

Gas and oxygen or ether should be used, chloroform being inadvisable owing to its depressant action reducing blood pressure.

Perhaps the only case in which spinal anæsthesia alone would be indicated would be that in which extensive pulmonary disease existed and an operation of urgency is required.

Where complete relaxation is required in a subject whose condition would contra-indicate a profound ether narcosis, a spinal anæsthetic combined with light ether narcosis would be the method of choice.

The increase in blood pressure brought about by the inhalation of a small quantity of ether vapour also tends to counteract the lowered blood pressure following the intradural injection.

(*b*) **Paravertebral Anæsthesia.** As the production of this and the following (splanchnic and parasacral) methods fall to the province of the surgeon rather than to that of the anæsthetist, only the outlines and principles of the methods will be described here. For details as to technique, etc., the reader is referred to special treatises on this subject.

By the paravertebral route the anæsthetic solution is introduced around the nerves near the spinal column, thereby blocking off from the central nervous system a definite area supplied by those nerves.

The drug used is novocaine, in 0·5 or 1 per cent. solution in sterile normal saline. The solution is injected around the nerves, and not into the sheaths, and from 100 to 200 c.c. of the 0·5 per cent. solution may be used. The glass barrel of the syringe is graduated to hold 25 c.c.; the needles used are of varying lengths, from 5 to 10 cm.

Definite landmarks at the side of the vertebral column are taken as points of entry of the needle to reach the required nerves as they leave the intervertebral foramina. Aspiration is always practised before introducing the solution to avoid the danger of intravenous injection.

(*c*) **Splanchnic Anæsthesia.** To produce splanchnic anæsthesia the anæsthetic solution is introduced around the semilunar ganglia, situated in the retroperitoneal space in the region of the adrenal bodies. By this means anæsthesia is produced in the stomach, small intestine, spleen, liver and gall-bladder. For operations on viscera in this region an additional infiltration of the abdominal recti muscles (field block) is required to produce relaxation and anæsthesia of the abdominal wall.

Novocaine, 0·5 per cent. in sterile saline, is employed, and up to 300 c.c. may be used. The solution is injected either from the back (Kappis' method) or anteriorly, opening the peritoneal cavity (Braun's method). The method is not without danger, owing to the close proximity of several important vessels. In every case the injection must be made separately on each side. The method is usually combined with a light narcosis, and for this ether and oxygen is the most suitable, a very small quantity only being required.

(*d*) **Parasacral Anæsthesia.** In this region the anæsthetic solution is introduced extradurally into the sacral canal to reach the trunks of the sacral and coccygeal nerves, cutting off the supply to the perineum, anus and genitalia.

Combined with a field block of the nerves supplying the mesosigmoid, operations on the rectum and, with the addition of field block in the uterine and ovarian ligaments, gynæcological operations may be undertaken under this method. Satisfactory performance of the injection is not easy and not without danger, and the method does not appear to possess advantages over that of spinal anæsthesia.

APPENDIX

WAR SURGERY

GUNSHOT wounds in war may be comprised under the headings of bullet and machine-gun wounds, shell wounds, and bomb wounds. In connection with air raids, certain other injuries are frequently seen, such as severe crushes, severe burns, wounds from flying glass, and deleterious effects from blast. In general it may be said that gunshot wounds differ from the ordinary wounds of civilian practice chiefly in their extent, in the violent forces employed and the great tendency for the projectile to carry in with it into the patient's tissues a vast variety of foreign material. Thus it is by no means uncommon to see pieces of clothing, bits of stone and rock, soil, mud, and even portions of another man's body, such as the fingers, carried deeply into the tissues when a severe gunshot wound has occurred. This tendency for the introduction of foreign material is naturally very much less marked in the case of high velocity pointed bullets than in the case of fragments of shells and bombs, while the larger the fragment of shell or bomb the more likely is foreign material to be found in the wound.

This introduction of outside matter is one of the causes of gross septic infection and the common incidence of both tetanus and gas gangrene which so frequently occur in gunshot wounds unless they are properly treated.

Wounds of the Soft Tissues. These naturally vary greatly in severity, and their treatment is governed very largely by the necessity for taking measures to prevent the onset of infection. Thus, in the last war, it became established as almost a routine that every wound should be freely and completely excised, a radical attempt being made to remove the edges of damaged skin together with the whole track of the projectile and any foreign material that was driven in. Naturally this was not possible in all cases, and in many instances it was a difficult and serious proceeding; but, if successfully effected, the wound could be loosely sutured and would often heal more or less by first intention. This still remains the standard procedure subject to the proviso that it is not always necessary in the case of small clean penetrating bullet-wounds, or in the case of multiple superficial small bomb wounds, while in the cases of severe shock so frequently seen among air-raid casualties it must certainly be delayed until the shock is adequately treated.

Shock and collapse are common in all engaged in active battle, consequent on the exposure, mental stress and terrors of aerial, etc., bombardment, and arise from these all apart from physical injury. It is most important to realise the great part mental strain plays in the production of shock and to treat this by the free administration of morphia or opium, which is well tolerated in gr. ⅓–½ doses, and should be repeated every three or four hours till the patient is recovered; should the respirations fall, even to five a minute, no anxiety need be felt unless cyanosis is present, in which case continuous oxygen must be administered. Of course, all other means of combating shock, rest, warmth and administration of hot, sweetened drinks must be carried out as advocated in Chapter IV., Vol. I.; in our experience transfusion of blood or plasma is seldom necessary unless there has been actual loss of blood, and even then not more than 1 or 2 pints is usually necessary or beneficial to the patient at one time.

Blood transfusion should usually be commenced when the patient is being anæsthetised prior to cleansing the wound. Stored blood or plasma is used if available, but a list of grouped donors in the units around should be kept in case the store fails. One or more special teams for transfusion should exist at each hospital or field medical unit. Full details as to procedure are given (Vol. I., Chapter IV).

Though it has always been recognised that shock is a common accompaniment of gunshot wounds, it has come as a surprise to many surgeons to note the magnitude and frequency of the shock associated with air-raid injuries. Though the extent of the shock in these cases is roughly proportionate to the injury, quite often almost minor injuries produce a most unexpected amount of collapse. This may be partly psychical in nature and be associated with the fact that the casualties are occurring in civilians who are wounded amidst their home surroundings rather than in the soldier who is highly trained, and to whom casualties come less unexpectedly.

In connection with air-raid casualties in particular, it should be remembered that, though many of them require operation fairly urgently, such as excision of wounds, putting up of fractures, etc., this should never be attempted in a badly-shocked patient until the shock has been adequately treated, and that even in patients who appear to be mildly shocked it sometimes happens that any operative procedure will greatly and gravely increase the collapse.

Burns. Burns are seen especially in connection with incendiary bombs, aeroplane crashes, high explosive discharges in confined spaces, as on ships or tanks, and air-raid casualties, and may be of a terrible degree of severity. There is little that need be added to the account of their pathology and treatment given in Chapter IV, but it is well to bear in mind that first aid plays a most important part with battle casualties and early coagulation with no prolonged attempt at cleansing, free administration of fluids and morphia, and rest are essential life-saving measures to be carried out promptly. In petrol burns where the temperature is very high, sepsis frequently does not supervene, but the burns may be very deep, and in such cases no attempt at recoagulation should be made in cases seen after forty hours from the application of the first-aid dressing; in all other cases cleaning and retanning is usually necessary as sepsis has supervened. Recently certain plastic surgeons have advanced the opinion that the usual routine treatment of burns by tannic acid provides such a firm casing of tanned tissue that œdematous fluids cannot escape and the subsequent contractures are thereby rendered far more severe. This, however, cannot be considered definitely established, and many surgeons consider that the extremely severe contractures which undoubtedly occur are probably more due to the depth and severity of the burns than to the tannic acid treatment. The problem is one which is only likely to arise in connection with the fingers, face, and more mobile parts of the body.

Alternative treatments which are, to a certain extent, replacing tannic acid are the application of what is known as " triple dye," and the immersion of burns in more or less continuous baths of hyperchlorites.

Fractures and wounds of joints are fully dealt with in Vol. I., Chapters XIV and XV., and in war such fractures are frequently open and complicated by severe injuries to surrounding tissues and great shock, so that their treatment though a matter of urgency usually should be delayed an hour or so till the patient has been revived, and then carried out deliberately but as rapidly as is compatible with complete excision of *all* damaged muscle, thorough hæmostasis and removal of all completely loose bits of bone. *Never* attempt suture of the soft parts if any tension is caused by such stitches, but leave the wound open. *Fixation* is best secured by *plaster of Paris* splintage, but these splints should be bivalved in all cases which are to be transported by car, ship or rail to another hospital, as thereby many lives and limbs are saved; when the patient will be treated for some length of time in the same or a nearby hospital the limb can be encased completely with benefit both to the patient's comfort and union of the fracture and prevention of œdema, but any evidence of pressure, pain or rise of pulse (denoting hæmorrhage or gas gangrene) must be an *immediate* indication for bivalving the plaster and examining the wound. *Extension* in lower limb fractures is best applied by means of pins or wires and a Thomas's splint applied in all these cases. This does not prevent the wound and seat of fracture being encased in plaster, and the extension can then be by weight from a balkan frame or be of a fixed type (which is necessary for transport).

In severe cases of compound fractures, especially where limbs are pulped or joints involved prompt amputation often saves life and prevents a long and painful convalescence with a useless limb as a result; similarly the presence of multiple wounds may determine amputation of a fractured limb as a life-saving procedure. If possible the opinion of an experienced surgeon should be obtained before amputation is carried out, but not at the price of undue delay.

Joints are frequently involved in bomb, gunshot and other wounds, and their diagnosis and treatment in no way differs from that described in Vol. I., Chapter XV. Infection is common and must be dealt with promptly by drainage down to the joint at its most dependent part while the patient is nursed as described in Vol. I., Chapter XV., in which case recovery with a fair range of movement is the rule, but it must not be forgotten that amputation may have to be resórted to promptly as a life-saving measure.

Crushes by Falling Masonry, etc. These are exceedingly common in connection with air raids, and roughly speaking it will be found that, during night raids, crushes are common and bomb wounds rare, whereas during day raids the reverse is the case. Nothing further need be said about the treatment of such crushes than has already been set down in Vol. I., Chapters XV, XVI, XVII and XVIII., and in connection with wounds and compound fractures in general.

GUNSHOT WOUNDS OF THE HEAD, FACE AND SPINE

Gunshot wounds of the head need prompt excision just as much as those elsewhere, for though in many cases irreparable damage to the central nervous system is present, much amelioration of this can be effected if sepsis is prevented. It must be remembered that head and spine cases stand transport badly and need to be kept for at least ten days in the hospital at which they have been operated on; it is better therefore to transfer such cases to special hospitals at the base if this is feasible. Head wounds fall into three classes:—

1. Those with no external wound, but underlying brain damage.
2. Those with penetrating wounds, and a rapid pulse, which are usually rapidly fatal following early onset of sepsis or cerebral compression.

3. Those with a large open wound with or without brain damage, with a slow pulse, and often full consciousness, while sepsis tends to localise; such usually recover especially with early surgery.

It must be remembered that though "tin hats" reduce the number of slighter head wounds they may aggravate the more severe by being driven into the brain by falling masonry, etc. In about 30 per cent. of cases other wounds are present in the same patient and need full attention. The signs and treatment of these conditions are fully dealt with in Vol. II., Chapters I and II., but there are certain points it may be well to emphasise.

1. All scalp wounds should be excised after infiltration with local anæsthetic.
2. All loose and depressed bone fragments must be removed.
3. If the dura is intact leave it unopened unless it is bulging, purple and pulseless.
4. If the dura is perforated enough bone must be removed to leave 2 inches of undamaged dura around the wound which is excised and the underlying brain *gently* searched for depressed bone and clothing, while pulped brain tissue is sucked out through a catheter. The dura is then closed *without* drainage, a fascial graft being inserted to fill any gap.
5. Unless an X-ray apparatus is available to localise them it is much better not to search for missiles deep in the brain.
6. *Never* drain head wounds, not even the scalp.

Wounds involving the sinuses (venous) are not uncommon and usually rapidly fatal, but in the case of small wounds they should be explored and treated as advocated in Chapter I., Vol. II. Never plug the sinuses in these cases (see also Vol. II., p. 24).

Wounds of the face and jaw are horrible and revolting to see, but in many cases the recovery is almost miraculous after prompt surgery and the resulting deformity surprisingly slight, and to ensure this preservation of tissue is of great importance.

The edges of such wounds should merely be trimmed and only completely detached bone fragments removed and the soft tissues sutured to retain others in position, provided NO tension is entailed. It is important to suture skin to mucous membrane, so as to prevent granulation and scarring.

In jaw fractures all damaged and decayed teeth must be removed, the patient fed nasally and the mouth and nose syringed regularly.

The general principles differ somewhat from those advocated as routine and early specialist co-operation is essential. It must be realised that great bruising and swelling is a normal accompaniment and is likely to be mistaken for cellulitis, but all septic complications are rare in facial wounds, and even tetanus when met with is mostly of a mild paralytic type.

Remember in double fractures of the front of the mandible the tongue may fall back and suffocate the patient, so that such cases must walk stooping forward or be carried face downwards and be instructed, if conscious, to place the finger in the mouth and pull the tongue forward when necessary; otherwise the tongue must be held forward by a stitch transfixing the top and looped around the ear. Tracheotomy is *never* necessary in these cases.

In **gunshot wounds of the spine,** inasmuch as indriven fragments may cause extensive circulatory disturbance and pain and give the impression that much greater damage is present than exists, prompt surgery is indicated to relieve these, but of course no improvement of those signs due to actual cord destruction can be expected. It is well to remember that the cord proper stops opposite the lower border of the first lumbar vertebra and that the corda equina below this level should be sutured if damaged (see suture of nerves, Vol. I., Chapter XII.).

Functional paraphlegia often occurs, but the paralysis is usually spastic and NO Babinski's sign is present, while *spinal concussion* (Vol. II, Chapter II.) is seen occasionally after burying accidents.

Fractures of the spinal column are frequent, mostly of the depressed type (Vol. II., Chapter II.), and surgery should be undertaken as early as possible to relieve pain and pressure, free exposure is essential and the general principles laid down for head injuries should guide the surgeon. In both these types of case sulphonamide should be given as a routine for a week. Fixation subsequently in plaster of Paris is necessary only where there is a fracture-dislocation or severe crush of a vertebral body.

Retention of urine is a common complication, and unless only transitory and due to relievable compression of the cord, should be treated at once by a suprapubic cystostomy as the risk of infection is greatly minimised by this means, and experience after the late war proves that cases treated by suprapubic cystostomy survive while those treated otherwise do not.

In regard to *first aid treatment* and carriage, it is best to move the patient on the stretcher in the position in which he is lying, rather than turn him so as to always carry him face downwards.

Gunshot wounds of peripheral nerves occur complicating larger wounds, and their treatment is carried out during excision of these—primary suture should be performed when this is done provided the nerve ends can be traced and approximated without undue tension (Vol. I., Chapter XII.) and suitable after-treatment instituted. When no suture is possible the nerve ends may be trimmed and ligated, with a view to subsequent nerve grafting or other suitable means to re-establish continuity (Vol. I., Chapter XII.).

ABDOMINAL WOUNDS

Under this heading are included those wounds which open the peritoneum, with the occasional exception of damage to the kidney, colon, bladder, or rectum in the extraperitoneal regions. It can be taken practically for certain that, if the peritoneum is opened, some intraperitoneal viscera will be damaged, and unfortunately these wounds are nearly always multiple. Conversely, it is exceedingly rare, but not unknown, for intraperitoneal viscera to be damaged by gunshot wounds which do not open the peritoneum. These wounds may be divided roughly into two classes, from the point of view of diagnosis: those where there are both entrance and exit wounds, and those where there is only an entrance wound. In this respect it must ever be borne in mind that wounds of the buttocks, perineum, chest and back should always be examined with the greatest care as they are very liable to involve pelvic or abdominal viscera.

(*a*) When both entrance and exit wounds are present, the diagnosis as to whether the peritoneal cavity is involved or not may be rendered easier by noting the course of the projectile between the two wounds. It is practically certain that this will be a straight line unless bone, such as the pelvis or spine, is struck on the way. In many cases, therefore, it will be obvious from this track that the peritoneal cavity is opened. There are, however, quite commonly cases which are doubtful from this point of view, owing to the thickness of the abdominal musculature. Thus, wounds will be seen where the entrance is at the side of the front of the abdomen and the exit is at the side of the loin, where the thickness of the bellies of the oblique muscles is such that the peritoneum has not been opened although it looks as though it must have been. The same condition is occasionally seen in wounds which traverse the abdomen from side to side, through the bellies of the recti muscles, without opening the peritoneum. Though, as has been said, help will be obtained in the diagnosis by noting the track of the wound, the greatest attention must be paid to the clinical signs of a perforating wound to be described later. It must also be remembered that around any wound in the abdominal wall, there will be an area of tenderness and muscular rigidity; and this must not necessarily be thought to indicate a perforated abdomen. The movements of respiration occasionally will suck a certain amount of air into a valvular wound in the abdominal wall, which will give rise to surgical emphysema for a short distance around. It must not therefore be thought that this crepitation in the tissues necessarily indicates either a perforation of the bowel or colon, or the onset of gas gangrene.

(*b*) When only an entrance wound is present, no idea of the track of the projectile can be obtained; though, if an urgent X-ray picture can be taken, this might help by showing the position of the projectile. It must particularly be remembered that wounds at quite a distance from the abdomen may nevertheless enter the peritoneum and do untold damage. Thus, *wounds of the buttock commonly do this, as also do wounds of the upper part of the thigh, the chest, the base of the neck and the perineum.* In the case of chest wounds, the diagnosis may be particularly difficult, as these will cause abdominal pain and rigidity even when they do not enter the abdominal cavity.

It must be remembered that, as these injuries are nearly always multiple, quite often both solid and hollow viscera will be damaged. The signs and symptoms of injury to the abdominal viscera are described in full in Vol. II., pp. 514–528; and here we need only recapitulate that, in the case of solid viscera, the signs and symptoms are mostly those of intraperitoneal hæmorrhage, with shock and tenderness over the injured viscus; while, in the case of injury to hollow viscera, marked shock with a rising pulse, onset of vomiting and increasing and spreading pain, rigidity and tenderness, will be the distinctive features.

Treatment. Once the diagnosis of a perforating wound of the peritoneum has been made, a laparotomy should be performed as soon as possible; though, in cases which are badly shocked, resuscitation treatment should be applied first. If it is really doubtful whether the peritoneum has been opened or not, the wound should not be probed, but it should be gradually incised layer by layer and the track followed up to see if the peritoneum is opened and then if necessary a laparotomy can be proceeded with immediately.

When the laparotomy is performed, unless there is evidence that the wound track is confined to some particular region of the abdomen—such as the left side or the epigastrium when the incision can be made in this neighbourhood—a right paramedian incision will usually be found to be the best. When the peritoneum is opened, much free blood will usually be found, which may come from liver or spleen, the mesentery, or the retroperitoneal tissues. The bowel itself does not often bleed very much, nor is it in the least likely that any extravasated intestinal contents will be found, though a fæculent odour may be noticed. It is almost certain that the injuries will be multiple, and therefore in most cases it is necessary to examine almost all the abdominal organs; although there are exceptions to this, as, for instance, if the wound is confined to the epigastrium, when it is not necessary to examine the rectum and bladder, or when it is confined to the pelvis, the stomach, liver and spleen need not be examined. In all cases, the whole of the bowel must be searched, and there are two ways of doing this. One method is to endeavour to follow the track of the wound and to examine any structure which may have been in the line of that track; but a far better method, and one which is much less likely to lead to injuries escaping notice, is deliberately to pass every coil of the small and large bowel through the fingers, the surgeon taking it out coil by coil and examining it, and the assistant putting it back, so that there is never more than one coil out at a time.

It is quite common to encounter four, six, eight or more holes in the bowel, with their characteristic pouting mucous membrane and absence of fæcal extraversation, and these may be accompanied by wounds in other organs too. In most cases these holes in the bowel can be sutured in one or two layers, but not infrequently, if the bowel is severely lacerated, if several large holes are present close to each other and above all, if the mesentery is seriously damaged, it will be wiser and quicker to resect the coil concerned and do an end to end anastomosis. Wounds of the bladder, rectum, stomach, spleen and liver, portal vein, and large vessels may have to be dealt with at the same time. If the patient has been wounded for more than four or six hours, definite peritonitis will be setting in and his chances of recovery are very much less.

There can be no question of the value of speed in these operations, not only because it is beneficial to the individual patient concerned, but also because an individual surgeon may be faced with a dozen or more of these cases all to be operated on as soon as possible. (See also Vol. II., pp. 514–528.)

Thoroughness in examination is, however, equally as important as speed, and must never be scamped.

Thoracic Injuries. These again consist of two main groups: small perforating wounds due to high velocity bullets, and larger lacerated wounds produced by shell or bomb fragments.

(*a*) Small perforating wounds due to machine-gun bullets frequently cause remarkably little trouble. In fact, it may be said that, unless they strike the heart, large blood-vessels or a large bronchus, very little treatment other than rest and morphia may be required, though the possibility of a hæmothorax forming must always be borne in mind. Wounds of the heart and large blood-vessels have already been described in Vol. II., p. 437.

(*b*) Larger lacerated wounds are of course far more serious, and their gravity and their treatment depend upon four factors: (1) the degree of laceration of the internal organs; (2) the amount of hæmorrhage that there has been or may be; (3) the size of the opening in the chest wall; (4) the liability to sepsis.

The importance of the size of the opening in the chest wall is that air will be sucked in and out through it by the respiratory movements, and this if in any degree marked will allow the mediastinum to flap to and fro, thus gravely incommoding the heart. As a general rule, therefore, these larger lacerated wounds will need operation urgently, the pleura being widely opened, the lacerated lung being sutured, or possibly resected if gravely damaged, all hæmorrhage stopped, and finally the opening in the chest wall securely closed and made as air-tight as possible. Subsequently, a hæmothorax or an empyema may form, and a watch must be kept for these complications. If a hæmothorax forms, no very active treatment need be undertaken as long as it is small and uninfected (as shown by the temperature chart); but if large and causing pressure or embarrassment to the heart, it should be aspirated either once or repeatedly. (See also Vol. II., pp. 437–438.)

With modern technique, the opening of the chest has become such a simple procedure that there is serious danger of many of these thoracic wounds being operated upon quite unnecessarily, and the enthusiastic young surgeon would do well to remember that they do not all require operation and that this should only be practised when there are definite indications that grave laceration of the viscera has occurred, that hæmorrhage is proceeding or that an air-sucking wound is perforating the chest wall.

Abdomino-thoracic Wounds. Gordon Taylor states that 9 per cent. of chest wounds and 12 per cent. of abdominal wounds in the Great War involve the other cavity and that their mortality is about 80 per cent. In our experience some 10 per cent. of wounds involve both cavities and the prognosis may be regarded as practically hopeless if hollow abdominal viscera are perforated. Most of these cases are very severely shocked, and resuscitation will work wonders in apparently moribund cases. It is generally wise to deal with the abdominal condition first and then if the patient's condition admits extend the incision into the thorax; in cases of open or ingravescent pneumothorax, however, the thoracic condition is obviously the more urgent and will take priority. In all cases involving the upper abdomen or chest it is wise to explore the diaphragm digitally to note if this organ is penetrated.

Gas infection and gas gangrene (Vol. I., Chapter VII.) are preventable by prompt and free excision of damaged tissue, especially muscles, which must be excised freely till they are red, contractile, and the vessels spurt.

Sulphanilamide, etc., certainly controls the toxæmia and should be given in all cases of gas infection, usually by the mouth in citric acid or lemon to aid rapid absorption, but in very acute cases by injection into the muscles and then by mouth. It is a noteworthy fact that in this war the *B. Welchii* seems to have lost much of its virulence or man to have developed an immunity, for many cases of gas infection of great extent survive which would certainly have died in the last war, and that in many instances without sulphanilamide.

Tetanus is fully dealt with in Vol. I., Chapter VI., as are **local and general infections.**

Wounds of the Blood Vessels. These are common in war injuries and are fully described in Chapter X, Vol. I. It is very largely as a result of war injuries and especially of wounds by machine-gun bullets and small bomb fragments that aneurysms of special arteries occur and during and after the late war they were very common. For this reason we here give a short description of these special aneurysms.

ANEURYSMS OF SPECIAL ARTERIES

Thoracic Aneurysms. These are chiefly of medical interest, both from the point of view of diagnosis and treatment. The clinical features depend upon the direction in which the sac enlarges, and they consist briefly of the following signs; a pulsating swelling either in the suprasternal notch or to the right of the sternum; an area of dulness on percussion and a shadow in the X-ray film; pain either in the chest, in the spine or down the arm; pressure on the veins or the air passages, giving rise to congestion, cyanosis and dyspnœa; on the œsophagus, causing dysphagia; on the recurrent laryngeal nerve, causing hoarseness and a brassy cough, or upon the phrenic nerves, interfering with the heart's action and respiration; inequality in the pupils and the radial pulses and the phenomenon known as a "tracheal tug" are often seen. There will be hypertrophy of the heart and alterations in the heart sounds on auscultation and often a systolic murmur audible all over the chest.

Treatment. In most cases the only treatment possible consists of ordinary general measures (see p. 272). Dyspnœa may arise from many causes: actual pressure on the air passages, interference with the phrenic nerve or irritation of the recurrent laryngeal nerve, but tracheotomy should never be undertaken for its relief, for if it is due to the first cause, tracheotomy will not relieve it, and if due to the other causes the operation will not be necessary. If the aneurysm projects from within the thoracic cavity, the Moore-Corradi method of wiring and electrolysis or Macewen's method of acupuncture (see p. 275) may be undertaken, and in some cases temporary improvement has followed upon this. Distal ligature has occasionally been practised for these cases, and ligature of the right carotid and the right subclavian has at times caused improvement, but this was possibly due to the rest in bed following the operation. The introduction of Colt's wire cage has been practised upon a few cases with partial success.

Abdominal Aneurysms. These are much less common than thoracic aneurysms, and though they occasionally arise in the smaller vessels, such as the mesenteric, renal, splenic, or hepatic arteries, their usual site is in the main aorta, either just above its cœliac axis branch, or else close to its bifurcation. Thus the condition will give rise to a characteristic pulsating swelling exhibiting true expansile pulsation, smooth and round, near the middle line of the abdomen, and either in the epigastrium or just above the umbilicus, as the case may be. It is more to the left than the right of the middle line, and may extend in any direction, especially into the left loin. A systolic murmur is always present over it, though a thrill is not often felt. Pain varies greatly. If due to erosion of the vertebræ it is in the back and resembles spinal caries, and in some such cases compression-paraplegia has occurred. If due to pressure on the lumbar nerves or solar plexus, it will be neuralgic, and may resemble renal colic or be thought to be due to indigestion. There may be œdema of the feet and legs, while the function of certain of the abdominal organs will be interfered with if they are pressed upon. If the femoral and radial pulses are compared, the former will be found to be delayed.

Diagnosis. The diagnosis has to be made from the "pulsating aorta," which is seen in the epigastrium of neurotic women with visceroptosis, and from tumours overlying the artery which receive a transmitted pulsation. An X-ray film will usually achieve this, while careful examination of the nature of the pulsation, especially with the patient in the genu-pectoral position, will help. Cardiac pulsation is often seen in the epigastrium, but this will come down from under the ribs and no swelling can be felt. These aneurysms usually prove fatal by rupture, but not for some time, and in many cases they appear to remain stationary for years. A few successes have been recorded by needling the sac, by the use of the wire cage, and by the Moore-Corradi method. For either of these methods to be employed, a laparotomy must be performed to give access to the sac. Ligature of the abdominal aorta has never so far proved successful, although one case survived for forty-eight days after the operation.

Should it be found on laparotomy that the aneurysm does not arise in the main aorta, but in the splenic or renal artery, as is not uncommon, the vessel may be tied, and the corresponding organ (spleen or kidney) removed.

Innominate Aneurysm. This is a rare condition, and is commonly associated with a similar condition in the aortic arch, being generally of the fusiform type. It gives rise to a characteristic pulsating tumour which commences behind the right sternoclavicular joint and sternomastoid muscle. It erodes or sometimes pushes forwards the sternum and right clavicle, and, after a time, projects so that it can be palpated either in the suprasternal notch or the subclavian triangle. There will be marked dulness behind the upper portion of the sternum, a systolic bruit will be audible, and the tumour will usually be visible in an X-ray film. The pulses in the right arm and right carotid are delayed and diminished, while pain is very often severe and due to pressure on the brachial plexus; this also may cause muscular weakness in the arm. The pupil on the right side will be contracted or dilated from paralysis or irritation of the sympathetic trunk, and this also will lead to hyperæmia and sweating of the right side of the face. There may be œdema of the right arm and right side of the face and neck; it must be remembered that the left innominate vein may also be pressed upon, this causing left-sided œdema; dyspnœa from pressure on the trachea or the recurrent laryngeal nerves, and occasionally even dysphagia, are also seen. The condition slowly progresses, and causes death either from rupture or suffocation.

Treatment. General medical treatment holds out little hope, and as proximal ligature is clearly impossible, we have to rely upon distal ligature in the form of Wardrop's operation. All the blood passing through the sac cannot be cut off, as this would involve ligature of the subclavian, carotid and vertebral arteries, and would be certain to cause serious cerebral symptoms. The best treatment, therefore, is ligature of the right common carotid and the third part of the right subclavian. These vessels must be ligatured simultaneously, for if an interval is allowed between their occlusion the setting up of a collateral circulation will ruin the prospects of success. Such risks as the operation carries, apart from difficulties of technique, are due to the tendency of a ligature of the common carotid to produce hemiplegia. This will be found to occur in about 25per cent. of cases, and it is a risk which must be faced. If these operative measures fail, needling or acupuncture will have to be tried.

Carotid Aneurysms. The common carotid artery is not uncommonly the seat of an aneurysm, this condition being seen especially in women, and being more frequent on the right side than on the left. When it occurs it is usually found to commence either near the bifurcation of the vessel or else at the root of the neck near its origin. Such an aneurysm progresses slowly, and gives rise to the usual pulsating swelling and other aneurysmal signs. Pressure effects are usually seen upon the sympathetic trunk, the vagus, the recurrent laryngeal and upon the larynx, œsophagus or trachea, while interference with the blood supply to the brain sometimes gives rise to cerebral symptoms. When the aneurysm is getting big dyspnœa may be very marked, and there may be a most distressing cough. Œsophageal pressure is only seen when the aneurysm is on the left side. When this aneurysm occurs low down in the neck it will resemble closely aneurysmal dilatations of the subclavian, innominate or aortic arch, and the distinction may be all the more difficult, because in some instances one of these vessels also may be dilated; however, an accurate history as to where the swelling first appeared, a careful examination of the upper part of the chest, of the swelling itself, and of the pressure effects will usually elucidate the point. The peripheral pulses in the radial and temporal arteries must be carefully examined. Thus if the radial and temporal pulses on the right side only are affected, the aneurysm is innominate. If only the radial is affected it is subclavian; if only the temporal is affected it is carotid. A similar method of distinction may be applied to the left side, but the fact that the presence of an aneurysmal sac often will press upon and obstruct other arteries in its neighbourhood must prevent us from placing too much reliance upon these signs. An X-ray film nearly always will be found helpful.

Certain pulsating tumours also occur in the neck, due to goitres or growths, which may give rise to difficulty in diagnosis. In this connection it must be remembered that apart from the general methods of distinguishing such swellings described on p. 269, goitres will move up and down on deglutition, while an aneurysm remains fixed; goitres are not, as a rule, confined to one side of the neck, but spread into the isthmus and possibly to the other side, they resemble the thyroid in shape, and their greatest point of fixity is in the midline and not at the side of the neck. The general methods of diagnosis described on p. 270 should also serve to distinguish the condition from enlarged lymph glands, cysts, abscesses and other tumours which are receiving a transmitted pulsation from a vessel close by.

Treatment. Simple ligature of the vessel is the treatment usually adopted, and this is usually found to be successful in curing the aneurysm, but it must be remembered that there is a distinct risk of hemiplegia following the operation. If the aneurysm is low down at the root of the neck, distal ligature (Brasdor's operation) of the common carotid above the omohyoid muscle should be performed, while if the swelling is high up near the bifurcation, a proximal ligature of the main vessel below the omohyoid will be the operation of choice. Excision of the sac does not, as a rule, give rise to any better results, and in this situation is a far more serious undertaking.

Aneurysms of the external carotid or of the internal carotid (extracranial portion) are seldom seen, except in association with a dilatation of the common trunk near its bifurcation. In either of these cases the pulsating swelling will be found above the thyroid cartilage and just below the angle of the jaw, while any pressure effects there may be will involve the hypoglossal nerve, the pharynx and larynx. In the case of the internal carotid the swelling tends to bulge in towards the pharynx, where it may present as a tense pulsating tumour under the mucous membrane near the tonsil. It will then closely resemble a supratonsilar abscess, and more than one of such cases has been incised under this false impression, with disastrous results.

Treatment. In the case of the external carotid an attempt should be made to isolate and tie the vessels entering and leaving the sac, which should then be dissected out. Failing this, it may be possible to tie the external carotid below where it enters the sac, but if this is impossible the common carotid must be ligatured. In the case of the internal carotid it is usually quite impossible to dissect out the sac, and in this case it will be necessary to tie both the common and external carotids, the latter being ligatured to prevent the blood reaching the sac by coming down this vessel through its many free anastomoses.

Intracranial Aneurysms. These involve either the basilar artery, the internal carotid or one of its branches, and they are nearly always due either to syphilis or the lodgment of emboli from disease of the cardiac valves. In most cases they cause no symptoms until they rupture, and the patient suddenly dies of apoplexy. In cases where such are suspected an arteriogram following injection of thorotrast into the internal carotid is of great value in establishing a diagnosis (Plate I., p. 255). When they do give rise to symptoms these are usually due in part to erosion of neighbouring bony tissues and in part to compression of the brain and rise of intracranial pressure with, in addition, a loud murmur usually audible to the patient. Apart from the pain and vomiting due to the general rise of pressure, various neurological signs will be found which are dependent upon the situation of the aneurysm. These aneurysms not infrequently occur close to the pituitary gland and may give rise to symptoms suggesting a pituitary tumour. They then come as an unpleasant surprise on attempting an exploration of the pituitary fossa. The condition is rarely diagnosed, and when it is, first one and then the other common carotid should be compressed against the tubercle of the sixth cervical vertebra with the fingers to see which, if either, relieves the murmur and symptoms most. On whichever side this is best effected the internal carotid should be ligatured. It is doubtful if it is ever worth while tying the vertebral artery for this condition.

Subclavian Aneurysm. This is most commonly seen on the right side in the male, and in those whose occupation consists largely in lifting and carrying weights on their shoulder. The third part of the artery is that most commonly affected, and the pulsating swelling is usually seen in the subclavian triangle just above the clavicle and just outside the sternomastoid: it is deeply placed and, in many cases, does not project much above the clavicle. As it increases in size it may press upon the pleura and lung, while it soon gives rise to œdema of the arm by pressure on the veins, referred pain, anæsthesia and weakness of the arm from pressure on the brachial plexus, and in some cases hiccough by pressing on the phrenic nerve. In many cases the first and only complaint is of pain in the hand. The radial pulse will be diminished and delayed, but stridor, huskiness of the voice and dysphagia never occur. The condition increases slowly but steadily, and ultimately the use of the arm may be completely lost. There are only two conditions which in the least resemble this: they are a soft, pulsating sarcoma, which may be distinguished by the general features given on p. 270; and also a normal subclavian vessel lifted up and pushed forwards either by a cervical rib (see Vol. II.), or by a prominent and high first rib. These latter conditions can be distinguished by an X-ray film, by the fact that they are usually bilateral, much more common in women, and by noting that the pulsating swelling can be felt to be narrow and elongated and to have the shape and size of the normal artery.

Treatment. The treatment of this condition is most difficult, and the results are often unsatisfactory. If possible, complete extirpation of the sac or Matas's suturing operation should be performed, but these operations are not often possible on account of the size and depth of the aneurysm and of the difficulty of getting access to the main vessel proximal to it. The next best procedure is proximal ligation, and this may have to be a ligation of the innominate vessel on the right side, in which case it should also be accompanied by a simultaneous ligature of the carotid, to prevent the blood flowing back into the sac down that vessel. Ligature of the first part of the subclavian is rarely possible as the aneurysm usually involves this part of the vessel also.

Distal ligature of the vessel immediately beyond the sac is an operation of less risk and difficulty, but its prospects of success are by no means as good, as the blood will still pass through the sac and find its way into the arm by collateral vessels. On account of this Sir William Ferguson suggested the operation of amputation at the shoulder joint combined with distal ligature as near the sac as possible, but this method should be adopted only if everything else has failed.

Axillary Aneurysm. This also is seen chiefly in men, who use their arms for heavy labour, and on the right side. In many cases it is definitely associated with an injury, such as a dislocated shoulder, or fractured humerus or clavicle, or the attempts made to reduce these injuries. Surrounded as it is by lax tissues, this aneurysm increases very rapidly, and may become very large, bulging out below into the axilla, pushing the clavicle forwards, and in some cases even extending upwards into the neck. Cases have even been described in which the ribs have been eroded and the lung compressed. In addition to the presence of the pulsating swelling, there is marked pain in the arm and hand with congestion and œdema and, in some cases, anæsthesia and weakness. Rupture is not uncommon, and has been known to occur externally, into the pleura and into the shoulder joint.

Treatment. Here again, if possible, complete excision of the sac should be performed, the pectoral muscles being cut across and sutured afterwards. Failing this, if it is possible, the third part of the subclavian vessel should be tied, while in a few cases, where the sac extends high up, the second part of this vessel will have to be ligatured.

Aneurysms of the Arm. Nearly all aneurysms occurring in the brachial, radial, ulnar or other vessels of the arm are traumatic. They are especially seen in the bend of the elbow, and were common in the days when the veins at this situation were frequently used for bleeding ; in all cases the best treatment, if possible, is extirpation of the sac. Failing this, the main vessel should be ligatured above and below the aneurysm.

Internal Iliac Aneurysm. This is a rare lesion and when it occurs usually fills the greater part of the pelvis. One has been recorded as the result of damage done when opening or plugging an ischiorectal abscess.

Inguinal Aneurysms. Aneurysms are seen not infrequently in the iliac and inguinal region, and in this situation they may have their origin in either the common or external iliac or the common femoral ; they usually appear in the first instance either immediately above or below Poupart's ligament. Such sacs are often constricted by this ligament, and owing to the denseness of the fascia lata of the thigh, it will be found that they tend to spread upwards towards the abdomen rather than down the leg : in time they will erode the iliac fossa and appear in the lower part of the loin. In addition to the typical pulsating swelling, which may be of large size, there will be pain, congestion and œdema of the limb below. These aneurysms are specially liable to be missed in their early stages, when the patient's only complaint may be of pain down the leg, which is thought to be due to sciatica.

In the later stages, and when big, such an aneurysm will resemble a pulsating sarcoma of the pelvic bones, more especially when it has perforated the bone and come through to the outer side of the iliac bone.

Treatment. Extirpation of the sac would be the best treatment if feasible, but it cannot often be performed, and in most cases a proximal ligature will be adopted. A proximal ligature should be performed as short a distance above the sac as possible, and, therefore, it will be placed upon either the external or common iliac ; the latter vessel is best tied by the transperitoneal method, but in the case of the former the older extraperitoneal methods of Abernethy and Cooper are quite satisfactory. The risks of gangrene following this operation are not great, and the results are usually excellent.

Femoral Aneurysms. By femoral aneurysm is meant one which forms in the femoral artery after it has given off its profunda branch or in the profunda branch itself. These are more commonly traumatic than pathological and the condition is usually seen at the apex of Scarpa's triangle, less commonly in Hunter's canal. It occurs in butchers who may injure their thigh with their knives. It gives rise to the characteristic pulsating swelling, with diminution and delay of the pulse in the limb beyond. If the aneurysm originates in the profunda femoris the pulse beyond, of course, will not be interfered with, while in many cases the main branch of the artery is pushed forward by the sac and can be felt pulsating separately from it.

The *treatment* of this condition should be a complete extirpation of the sac if possible. If this cannot be done, any of the other methods are applicable, and ligature of the main vessel a short distance above the sac is the most favourable procedure.

Popliteal Aneurysm. This is the most common form of aneurysm seen in the limbs. It is far more common in men than in women, and in a fair percentage of cases is bilateral. In some cases it is due to disease of the artery, in others to the lodgment of emboli, while it is probable that the continual flexion and extension movements of the joint play a part in its formation. At one time it was particularly common in post-boys owing to their continuous life on horseback. The patient complains chiefly of pain and stiffness in the knee, and the condition thus closely resembles chronic rheumatoid or other disease of the knee joint, for which it is often mistaken. The characteristic pulsating swelling is found in the popliteal space, while in addition there may be congestion and œdema of the foot and leg, severe pain, cramp and weakness from pressure on nerves, and, in some cases, actual gangrene of the foot, while the knee is often held partly flexed. This aneurysm usually increases in size rapidly, while if the swelling occurs chiefly in front of the vessel, the bones may be eroded and the knee joint often opened. There should be no difficulty in diagnosing it from nonpulsating swellings, such as diseased bursæ, enlarged glands or abscesses, but a pulsating sarcoma of the femur or tibia may closely resemble it. Here attention must be paid to the general principles enunciated on p. 271; after the condition has progressed for a few weeks differentiation will be easy.

Treatment. Many cases of this condition have been cured by compression of the vessel above, but the best treatment is a proximal ligation of the main vessel, either at the apex of Scarpa's triangle or, better still, in Hunter's canal, and the prognosis of this operation is excellent. Extirpation of the sac is not very suitable for an aneurysm in this position on account of the adhesions to important nerves close by, and the risk of gangrene which may follow it. Aneurysmorrhaphy on the other hand carries little risk of gangrene and would be the ideal operation except that, from the shape of the sac, it is often impossible.

Aneurysms of the Leg and Foot are always traumatic and very rare. They can be cured easily, either by excision of the sac or by simple ligature of the vessel above and below.

Gluteal Aneurysms. Aneurysmal swellings are occasionally seen in the buttock, where they are nearly always traumatic. If arising in the gluteal artery the swelling at its commencement will lie at the upper part of the sciatic notch, while if it commences in the sciatic artery it will be found to be lower down and more deeply placed. By the time these swellings have reached a large size it is usually impossible to say in which vessel they have originated. They give rise to considerable limitation of the movements of the hip on account of their involvement of the gluteal muscles, while pain down the sciatic nerve is a prominent and early feature. They will closely resemble pulsating sarcomata of the pelvic bones in some cases, while in others, where there is a considerable amount of pain and some overlying superficial œdema, there will be a marked and dangerous resemblance to an abscess.

Treatment. The only method of treatment likely to prove successful is a transperitoneal ligature of the internal iliac artery. Any approach upon the sac from the buttock or attempt to excise the sac wall will be dangerous, as the aneurysm often extends inwards through the notch into the pelvis, so that it is impossible to obtain control of the main vessel proximal to the aneurysm.

ARTERIO-VENOUS ANEURYSMS are fully dealt with in Chapter X, Vol. I, and in regard to these it must be emphasised that the presence of persistent tachycardia in the case of a patient with an uninfected wound is pathognomonic of a developing arterio-venous lesion.

WOUNDS OF THE HEART AND PERICARDIUM AND GREAT VESSELS. These conditions are dealt with in Chapter XI, Vol. II, and inasmuch as they are usually rapidly fatal offer very little scope for surgery under war conditions.

TREATMENT OF "GAS" CASES

"Gas." It should be realised that the term "gas" is very loosely used, and includes any chemical substance—solid, fluid or gas—employed for its poisonous or irritant effect. Such gases fall into five definite categories :—

(*a*) *Vesicants, e.g.*, mustard gas and lewisite.

(*b*) *Lung irritants, e.g.*, phosgene and chlorine.

(*c*) *Sensory irritants*, including lachrymators, *e.g.*, diphenylchlorarsine, bromobenzyl cyanide and chloroacetophenone.

(*d*) *Paralysants, e.g.*, hydrocyanic acid gas.

(*e*) Gases which interfere with the respiratory function of the blood, *e.g.*, carbon monoxide.

Generally speaking, only the gases in groups (*b*) and (*d*) are fatal in their effects ; while those in group (*c*) are capable of immediately, though only temporarily, putting the victims out of action. Those in group (*a*) have the power of producing intense irritation and incapacitating, far in excess of killing, when used against people trained in defence against gas.

It is proposed to consider briefly the various groups, together with the signs and symptoms produced, and to discuss the treatment appropriate to each variety.

Box Respirator. It must be clearly understood that a properly fitting and adjusted box respirator of the type illustrated in Figs. 398, 399 and 400 is the best protection against all types of gas poisoning. This respirator consists essentially of : (i) a metal box filled with chemicals designed to remove poisonous matter from the air which passes through it, connecting with (ii) a rubber face-piece —with glass eye-holes—to protect the eyes from gas, and which, by close fitting, ensures that only air which is passed through the box can be breathed ;

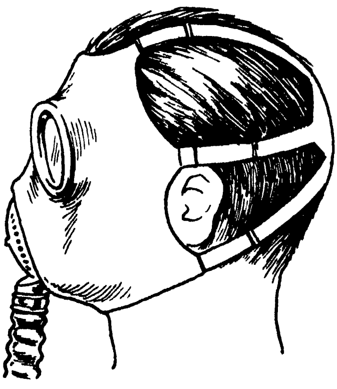


FIG. 398. Box respirator.

valves are arranged to guide the circulation of the air. It must be realised that the chemicals become used up in time, and need renewal if they are to maintain their efficiency against gases. It is very exhausting to wear the gas mask for prolonged periods, especially if physical work is engaged in during this period.

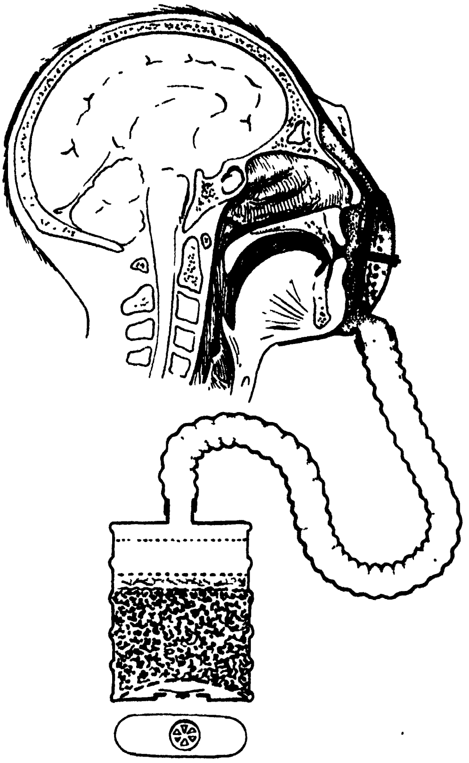


FIG. 399. Sagittal section showing box respirator in position.

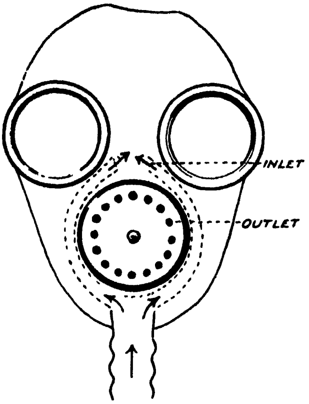


FIG. 400. Box respirator. Front view.

Protective Clothing. Protective clothing and boots, best made of oiled silk, should be worn wherever possible, especially in dealing with mustard gas. But, again, such clothing—preventing the evaporation of sweat from the body surface—leads to great exhaustion and cannot be long tolerated. In this connection it may be mentioned that mustard gas will penetrate in time through ordinary surgical rubber gloves which, therefore, form an inadequate protection, as do ordinary leather boots.

(*a*) **Vesicants.** The chief vesicant is *mustard gas*, which is a clear, colourless, oily fluid with a faint characteristic odour described by some people as resembling new-mown hay, and likened by others to field mustard or garlic. In general, it may be said that the detection of its presence varies with individuals, each of whom must accustom himself to detecting the slightly acrid smell of its presence. This fluid is capable of dissolving in water to a slight extent, sufficient to contaminate it temporarily, while it evaporates slowly at 100° F., and is therefore very persistent in its action.

Lewisite is a somewhat similar liquid, which, however, acts immediately and in addition may produce signs of arsenical poisoning.

Both these gases may be used as spray from low flying aeroplanes.

Signs and Symptoms. It should be noted that mustard gas is a substance which produces delayed action, *i.e.*, it is some time after detection of the liquid, or inhalation of the gas, before symptoms of toxicity manifest themselves. It follows, therefore, that if the oily substance is promptly removed, no harm will follow. If, however, the fluid is left in contact with the skin, or if contaminated clothing is not removed immediately, in about two or three hours intense itching together with soreness of the skin will develop gradually, while examination shows the area to be red and œdematous, and ultimately vesication develops (Fig. 401). At the end of twenty-four hours a severe burn is present, with large blisters, erythema, and—in the region of the scrotum (a part often affected owing to the patient having sat on contaminated ground)—great œdema is present. It should be noticed that frequently these blisters break down and lead to ulceration, which ulcers are extremely slow in healing, and often result in a painful scar.

At the same time, evaporation of the fluid and its presence in the atmosphere cause the development of a conjunctivitis which usually manifests itself an hour after exposure; there being intense lachrymation, and subsequently chemosis and blepharospasm. Rhinitis also develops, with intense headache from congestion of the nasal sinuses, and nausea and vomiting are not uncommon, owing to irritation of the pharyngeal and gastric mucous membranes. Later laryngitis and bronchitis become manifest, though these are not generally severe until at least twenty-four hours after the original exposure to the gas. In severe cases, large sloughs of necrotic mucous membrane are coughed up, while cyanosis and cardiac dilatation—and subsequent failure—lead to a fatal end, generally in from five to ten days after exposure.

FIG. 401. Mustard gas burns of buttocks, caused by sitting on contaminated ground.

Treatment. Care must be taken to avoid entering a contaminated area, unless with a box respirator adjusted in position, and dressed in protective clothing. It must be realised that an area which is contaminated with the oily mustard gas fluid will remain so, under ordinary weather conditions, for several weeks, unless adequate cleaning up of the gas has been carried out. It is equally important to grasp the impossibility of assisting casualties contaminated with the gas before protective clothing and a gas mask have been put on, otherwise contamination of the rescuer will be inevitable; for the same reason all casualties must have their clothing, etc., removed before they are admitted into gas-proof hospital wards, and these wards should be reserved solely for this type of case.

In dealing with a casualty the victim's gas mask should be adjusted, then all contaminated clothing should be removed and placed in a receptacle specially prepared for it. Such receptacles may take the form of oilskin sacks, or a tank filled with a solution of bleaching powder ; if bags are used, they should be conveyed to a steam steriliser for de-contamination. The patient, having been freed from contaminated clothing, should be immersed in water and thoroughly washed with soap and changes of water, and this process should take at least five minutes ; alternatively, the part should be washed for several minutes with a 2 per cent. solution of sodium bicarbonate. After this, if actual contamination is suspected, and as a first-aid measure if no bathing is available, the skin should be well rubbed with a cream of two parts of bleaching powder to one of vaseline ; or a paste of bleaching powder and water should be applied to the area, and left there for five minutes before removal. Bleaching powder, of course, must not be allowed to get into the eyes, and should not be used if an obvious burn of the skin is present. The patient can then be clothed in clean garments and put to bed.

Where a burn has actually occurred, following neutralisation of the gas, it should be treated with a tannic acid compress, as already described in the treatment of burns. The eyes, if affected, should be irrigated with a 2 per cent. sodium bicarbonate solution, and subsequently a drop or two of castor oil, containing 1 per cent. atropin, should be left in the eye. It must be realised that even one drop of liquid gas to the eye produces permanent blindness ; protection from spray by some form of eye shield is therefore essential.

Contaminated vehicles, furniture, etc., should be washed over either with petrol or a solution of bleaching powder. No attempt is made here to describe the various methods by which rooms and buildings may be rendered gas-proof, as these steps come under the control, not of the medical profession, but of the municipal authorities and their engineering advisers.

(*b*) **Lung Irritants.** Phosgene and chlorine produce a rapid and intense pulmonary œdema and bronchitis, which lead to rapid death from suffocation unless treated promptly. Quantities of thin fluid run from the mouth, and may choke the patient unless the head is turned to one side. The patient becomes firstly flushed with respiratory embarrassment together with epigastric pain, and, if not treated at once, passes through a stage of cyanosis to one of collapse, and shortly dies of acute pulmonary œdema.

The prompt wearing of a gas mask as soon as phosgene or chlorine is detected in the air will prevent the development of this distressing pulmonary embarrassment, but once it has developed, the mask will not be tolerated, and the immediate removal of the patient from the affected area, together with the use of the Haldane oxygen-carbon-dioxide apparatus—usually for ten minutes every half hour—is the best that can be done to relieve the symptoms, which in severe cases are rapidly fatal. Atropin and cardiac stimulants may be given, and, once the acute stage is past, expectorant mixtures will help recovery.

(*c*) **Sensory Irritants.** These are generally used in the form of finely divided particles of various organic arsenical compounds in suspension, the best-known gas of this group being " tear gas."

Signs and Symptoms. These consist in an immediate and characteristic onset of intense pain of a burning nature in the nose and throat, repeated sneezing and intense lachrymation, which are swiftly succeeded by running of the nose, salivation, nausea and vomiting. In severe cases the victim suffers from very acute tenesmus, though diarrhœa practically never occurs Removal from the source of irritation is followed by rapid disappearance of all these distressing symptoms. There is subsequent mental depression with some gases.

Treatment. The wearing of the box respirator, properly adjusted, will prevent any ill effects from these sensory irritant gases, while the best treatment consists in irrigation of the eyes, nose and mouth with 2 per cent. sodium bicarbonate solution, followed by inhalation of menthol. In severe cases light chloroform anæsthesia may be induced.

Groups (d) and (e). It is not proposed in a text-book of surgery to discuss either the mode of action or the rapidly fatal results which ensue from the inhalation of either hydrocyanic acid gas or carbon monoxide. The wearing of the box respirator is an efficient prophylactic in the case of hydrocyanic acid gas, but it must be realised that it is not so with carbon monoxide, in which case only the use of a special oxygen-breathing apparatus affords protection.

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PRINTED IN GREAT BRITAIN BY THE WHITEFRIARS PRESS LTD.
LONDON AND TONBRIDGE